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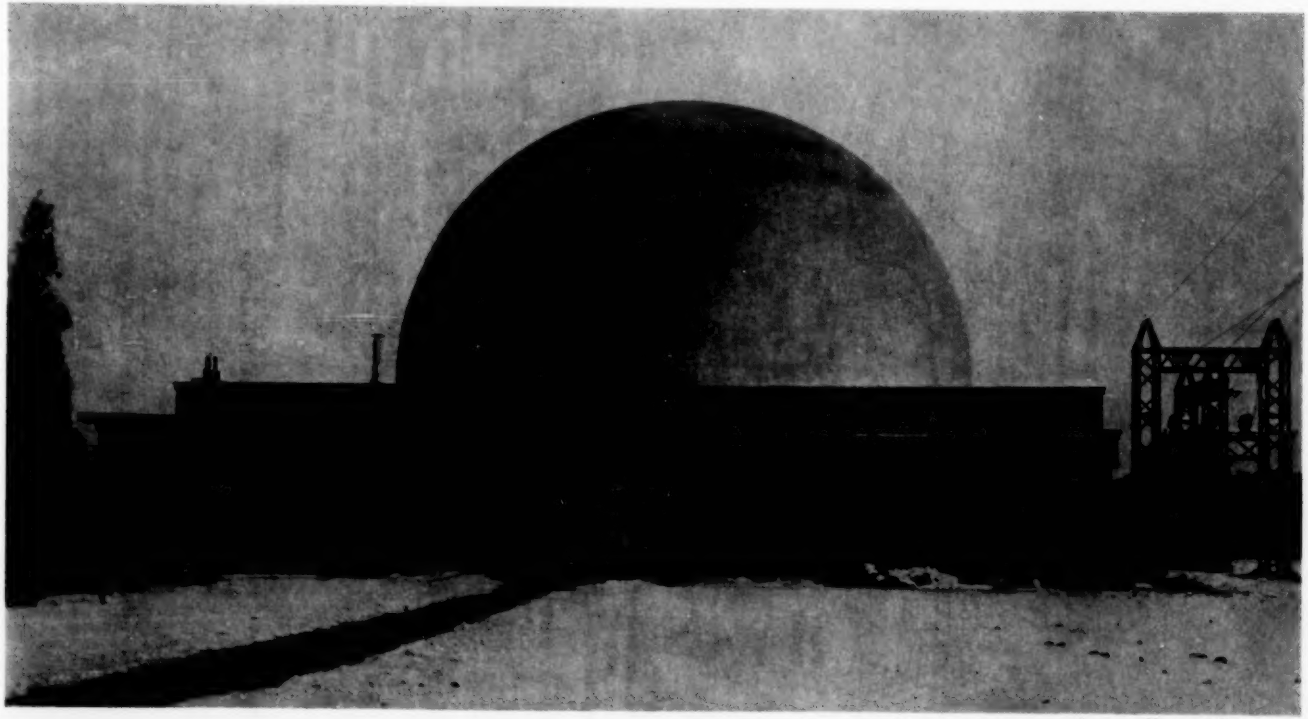

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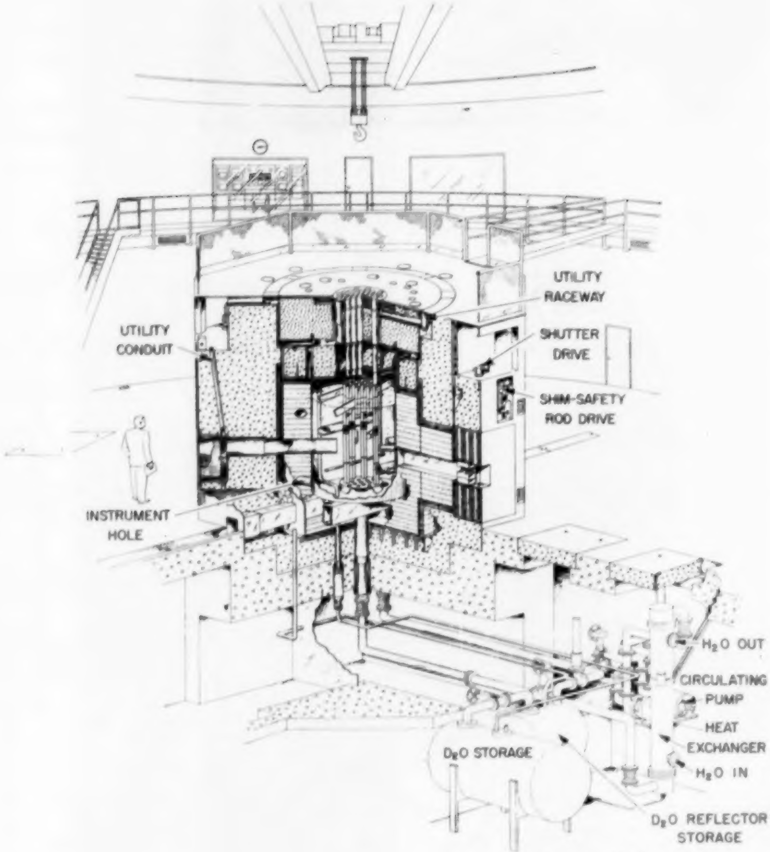

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When the skies are overarching,
In their blue of dazzling splendor,
And the airs, through leafy forests,
Call in whispers low and tender;
When each rosy morn is wakened
By the vows of some bird lover,
And the honeybees still linger
'Mid the dewy blooms of clover;
When, all melody and beauty,
Earth in sweetest calm reposes,
Then Heaven's fairest gift is given—
She is crowned with sweet June roses.

—MRS. HETTIE ATHON MORRISON, *June Roses.*

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SCHOOL SCIENCE AND MATHEMATICS

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PRINCIPLES OF CONSERVATION THAT ARE IMPORTANT IN SCIENCE*

Edward M. Ray

Michigan Department of Conservation

Conservation covers the waterfront in human interest. It deals with all material aspects of man's environment, and his social, economic, and political structure determines how much and at what rate he uses natural resources. In cases where human populations are in balance with natural resources that support them, there exists a foundation for further human progress and the possible development of gracious and effective living. We, in this country, have been using natural resources at an ever increasing rate per capita wise, and our population is increasing at an astonishing rate. This basic fact poses serious problems for school people everywhere. Although the problems are not new to our age or culture, they do have a new and urgent emphasis. Where the curves of human populations and resources supply will cross no one knows, but this much we do know that with technological advances the rate of use of natural resources increases rapidly and resource use problems become more critical. With these complications come many immediate problems. For the school people many of these problems are administrative; yet many of the problems present choices for teachers to make. Upon the choices that the teacher makes will determine the effectiveness of the total school program. Of course, the school administrators should be vitally concerned with these choices also.

The problem of what the future citizen needs to know is perhaps the most vital of the many problems confronting school people today.

* Paper presented to the Conservation Section of the Central Association of Science and Mathematics Teachers, Inc., Chicago, Illinois, November 23, 1956.

The citizen of tomorrow needs to know all of the basic information former generations needed to know but much more in addition. Inasmuch as we are living in a scientific age, the citizens of tomorrow certainly will need to have a science as well as a social science background in order to function properly as members of society. A proper science background will help him to interpret and understand his environment or, at least, will enable him to appreciate natural things about him. These myriads of living things are responsible for his existence. The citizen of tomorrow needs to be taught this. There seems to be too much idle talk about science being able to circumvent natural processes. Regardless of technological advances, man seems to be foredoomed to deal with natural resources in every application of scientific principle.

A science background would, we believe, serve to develop in youngsters certain skills highly useful at present or in the future.[1] The Michigan Science Teachers Association in a recent study listed the following skills as highly desirable outcomes of science teaching:

Abilities.

1. To observe and report accurately.
2. Locate, comprehend, organize, and retain information.
3. Compare objects and phenomena and to recognize their likenesses and differences.
4. Distinguish between relevant and irrelevant information.
5. Appreciate nature.

Other school subjects would have an interest and a part to play in the development of most, if not all, of these skills but some of the skills could better be developed in science courses than in other subjects because of the nature of subject matter in the science field.

To develop in students the ability to observe and report accurately is of cardinal importance in the science field, and the development of such a skill should be one of the major objectives in science teaching. This skill would certainly rank with any of the communication skills in importance. Accurate observation is not a simple skill to develop. Its development depends upon many factors among which are interest, attention span, previous knowledge, communication skill, etc. To be able to compare objects or phenomena and show likenesses and differences also is very appropriate to the science field and may well be a second objective of the science teaching.

A student of Dr. Agassiz relates a story concerning a great teacher and notes the impact the incident had on him. In a zoology class,

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[1] A Curriculum Structure for Science Teaching in Michigan, Dr. George C. Mallison, Michigan Science Teachers Association, Western Michigan College of Education, Kalamazoo, Michigan.

Prof. Agassiz gave him a fish to study for an hour with the request that he report on it in an hour. The student took the fish and looked at it for a while, then occupied himself with other things. When he was called in to report, the student reported that he saw nothing but a fish. The teacher asked him to spend another hour on the task assigned. This time the student examined the fish carefully and questions began to arise in the student's mind. He noticed that the fish had no ears. How did it hear? He noticed the shape of the fish. How did its shape benefit the fish? How did the fish breathe and taste? How were the fins of use to the fish? When the second hour was up, the student, not the Professor, asked the questions. This student had made some accurate observations and comparisons.

Science knowledge just for the sake of the knowledge is of minor importance as compared to the development of accurate observation and techniques of examination. These are skills that will outlive retention of facts and will become a part of the behavior pattern of the individual.

The average science teacher may view the area of conservation as rather limited in its scope. Most of the publicity on conservation is about hunting, fishing, or forest management, but the subject deals with all natural resources and their use by people. Man, too, is a natural resource, and his everyday living relates him to every field of natural resources. Conservation philosophy concerns itself with the wisest use and the best management of natural resources for people. The key word in the philosophy is USE. With the minor exception of preservation of natural areas the word USE has no connotation of saving or hoarding natural resources. This in itself is a principle that should be taught in our schools. This principle is applicable in all of the sciences and should be treated in each science area from whatever subject matter approach that offers the best opportunity. Perhaps most science teachers and the public generally think of conservation as relegated to the biological field, but it is just as applicable to the physical science field as well as to the social science field.

What are some of the conservation principles and in what subjects can they best be taught? The answer is that many phases of conservation can be taught in all school subjects. Some of the principles can be taught in specific subjects better because the subject matter covered offers the better opportunity.

One of the cardinal principles of conservation deals with management of renewable resources on a sustained yield basis. This means that living things can be managed to insure continued yield. This principle is not as simple as it seems, for in order to stay in business in growing living things, one needs to know the peculiarities of the plants and animals concerned and also land and water capabilities. In the

final analysis the condition of the land and water areas will determine what can or cannot be grown. One needs to know also how to repair damages resulting from continued use of areas. If man has the knowledge his management of renewable resources can produce far more than nature would do on her own. In other words, man can improve on nature by applying technological information to his management program. This is true of agriculture, forest management, fish and wildlife management, or of any other area of living things. Research has shown this, and it seems to be a simple thing to apply the best management practices to all of our renewable resources and reap an abundance of everything. In logic this is possible, but in practical analysis it doesn't work out that way because decisions on practices rest with people of various degrees of knowledge. This basically is the reason why conservation education must be taught in our schools, so that we will have an informed public on conservation matters. Resource use and resource management decisions must be made. If the decisions are wrong we all lose, but if right we all gain. At present, we are destroying the means of our economic base, our best land, faster than we are rebuilding or reclaiming it. Land can be managed on a sustained yield basis. This is a principle involving the whole field of science, including economics. The sciences furnish information on resource management, and in many cases the principles of science and principles of conservation are synonymous.

The sustained yield principle offers a wonderful opportunity to teach ecology of living things. The principle of the interdependency of living things is much more important than mere facts relating to living things. This approach to biology teaching makes biology a functional subject rather than an academic one. To be sure, it is easier to teach academic biology and hope that there is some transfer of learning. It takes a well-trained teacher to teach functional biology, but the rewards for both the teacher and the student are much greater. Dynamic teaching can be done through controlled experiments, field trips, and simple research problems suggested by the students, or by many other techniques. A biology teacher may not have the ideal situation in which to teach this type of material but there are opportunities to teach the principles even if the outdoor laboratory situation is lacking. The school yard or a vacant lot may become the outdoor laboratory. In these situations, the teacher may want to approach the problem of land yield from the standpoint of what are the limiting factors and how does man and his economy determine the ecological relationships. In many instances, local environmental study will be a study of an artificial area. This, nevertheless, has a great value in teaching principles of relationship of living things to man and his activity. The student finds many things of interest when

he begins to study any area whether natural or artificial. The area then becomes a system of living things including man.

Another attractive approach would be analyzing an area of living things as they are, then through source material and historical references determine what the area would be without the influence of man. This approach could well illustrate the conservation principle that of all of the forces determining change of living things in an environment, man is by far the most important factor. His action brings about complete and quick changes that are long lasting.

The ecological approach in biology can teach beautifully the principle that all life is dependent on plant life. Completely sterile soil will produce nothing. Plants, microscopic and otherwise, condition their own environment, and they are the determinates of what land and water can produce. Animals fit neatly into the picture for they control plant processes, retard plant succession or advance it according to the food habits of animal involved. Plants that animals like to eat will disappear when animal populations build up, and those plants animals do not like will thrive. Thus, animals, too, bring about environmental change.

Plant succession is an important aspect of renewable resource management. This is a topic that should be delayed for advanced high school biology. To understand it, one needs to do considerable field work, but it is not too complicated for advanced biology students There are differences that arise among the experts but simple plant succession in the Lake States area (other areas will have different climax forest types) may be divided into nine stages in cases of well drained land. They are:

1. Bare ground which contains yeasts, molds, bacteria.
2. Lichens, mosses, yielding to
3. Grasses, yielding to
4. Annuals, yielding space to the development of
5. Perennials, grading into
6. Shrubs, yielding environment to
7. Intolerant trees, which are usually the first tree species, then
8. Mid-tolerant trees, finally yielding to climax species which are
9. Tolerant trees.

It is rare that one will find a solid stand in any of the later stages but the key to categorizing the stage in question is that dominance in numbers determines the stage. Plant succession is determined by soil accumulation and water holding ability of the soil and happenstance. Learning the principles of plant succession is one of the most rewarding experiences that a biologist can have. It, too, becomes a lifetime interest on which many facts can be based.

The principles mentioned above are all functional biology problems that make biology mean something to the student other than that of gathering facts. These problems show the dynamics of nature and point up the fact that the only constant in nature is *change*.

Resource management makes use of most, if not all, scientific principles in one way or another. There was a time in conservation when management was based on opinion or trial and error methods, but not any more. Research done in most areas of science now points the way to wise resource management.

General science is full of principles applicable to the field of conservation. In this subject the principles that the teacher uses to apply to conservation are almost unlimited, and the ones used will likely depend upon the understanding and background the teacher has. The fields of weather, earth history, nature study, as well as many other fields have direct conservation application. In these and many other fields, the teacher has the opportunity to apply conservation principles. The conservation approach may become a framework on which facts are attached. Facts have a meaning when they are related to a workable philosophy. Principles which are more important than isolated facts also have a more significant meaning when they are shown as functional principles.

In chemistry and physics there are perhaps not as many general principles to apply to conservation, but there are nevertheless many opportunities to emphasize conservation. The use that is made by man of metals and chemicals is a dynamic story. The difference between stone age cultures and modern cultures resulted from man's use of minerals to make tools. Specialized tools enabled him to make things from natural resources that satisfied his needs for food, shelter, and clothing. This approach opens up the field of technological developments which have a definite bearing on resource use and man's progress. Most text books give a smattering account of uses of chemicals and minerals but not enough to give the student an understanding of the part minerals and chemicals play in our everyday living. In other words, physics, chemistry, and geology may be predominately academic, yet, these subjects as well as other fields of science might be functional in nature. Functional science, in whatever field, serves a better purpose than academic science. The functional approach weeds out much superfluous information and makes for an interesting and happy learning situation. Here again the key to the approach is use that man makes of the myriad of things about him. It has been said that ecology is the foundation for conservation philosophy and it may be but one could have a course in ecology and never touch conservation; or one could have a course in nature study without ever touching the field of conservation. Yet, emphasizing the use

angle makes knowledge in any science field live and gives it importance. Ecology or nature study should involve conservation for both of these areas of learning offer background for understanding conservation.

In a science course, failing to emphasize the use that an organism has in its environment or the use it is to man would perhaps place a science subject on an academic basis. With emphasis placed on use the whole panarama of science knowledge evolves into a picture of man's social, economic, and political life. This is the conservation approach, and it has application to every individual wherever he may live. Conservation education therefore cuts across all areas of learning. This fact makes it important for conservation principles to be taught in all school subjects.

The teacher does not have to be an authority in the field of conservation in order to do a good job teaching it. If the teacher understands the philosophy of conservation and the principles relating to it, certain objectives of teaching conservation become apparent. The objective may be acquainting the student with his total environment. The factual information that the student studies should become usable to him in understanding a principle controlling his environment. There is a danger that the science teacher will teach the facts and leave the student to his own devices to draw conclusions or relate the knowledge to a principle, which the student may never do. The conclusions may be obvious to the teacher but not to the student. The teacher should see to it that the objectives are reached regardless of what approach to teaching is used. In the process of teaching students to think for themselves, the science teacher may want to have the students evaluate the knowledge assembled and come up with principles of their own. Depending upon educational level with which the science teacher deals, the principles may first be studied then factual information may be used to show the reason for the principle. Principles of conservation apply in almost every area of science. Science provides the framework for resource management, and good conservation is the result of science application. Almost all scientific principles have application in some area of conservation. The science teacher has innumerable opportunities to relate scientific facts and principles to conservation teaching. There are many basic reasons why science teachers should concern themselves with teaching conservation, among which are the following:

1. Conservation is predominately a social problem in its application. Education is the means of solving many of our resource use problems. Conservation is a matter of applying knowledge for the common good of people.

2. Economic gain results from good conservation practices.
3. Resource management often becomes a controversial issue on which citizens vote. In order for a citizen to cast a wise vote, the voter must know the philosophy and principles of conservation.
4. Conservation practices and management change with shifting pressures and needs of people. The people need to be informed on conservation matters in order to evaluate these changes.
5. Many phases of conservation can be better taught in science courses than any other subject area.

HETEROGENEOUS IDEAS FOR INTERESTING DISCUSSION. III

JULIUS SUMNER MILLER
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With this third installment of *Heterogeneous Ideas for Interesting Discussion* I am led to ask for your reactions. In the preamble to Part I we set forth our purpose. (The personal *I* is momentarily replaced by the editorial *we*). Is our ambition met? Are these things useful to you and to your teaching? I invite your commentaries.

1. What effect has the flow of sand in an hour-glass on the total weight of the hour-glass during the time of flow? Remember that at the beginning there is sand in transit while there is no impact, and at the end there will be impact without a complete column of sand in transit.

2. Two men stand on a flatcar, one on each end, and play "catch." The car moves at uniform speed u. The ball is thrown with a speed v back and forth. Does one man do more work than the other?

3. A man carrying 3 billiard balls comes to a bridge which can bear his weight and *only one* ball at a time. He knows a little physics and decides to juggle the balls as he crosses so as to have only one ball in hand at any time. *Is this good physics?*

4. Two trains of equal length pass each other on parallel tracks in opposite directions, each going 50 mph. An observer in one notes that it takes the other 4 seconds to pass him. How long are the trains?

5. A uniform rod of negligible cross-section stands on end on a perfectly smooth horizontal plane. It falls over. What is the path of its midpoint?

6. In the firing of a rifle the recoil ***momentum*** of the rifle is equal to the forward ***momentum*** of the bullet. The ***kinetic energy*** of the rifle is NOT equal to the ***kinetic energy*** of the bullet. Show that this classical case illustrates the fundamental distinction between ***work*** and ***momentum.***

LECTURE DEMONSTRATIONS IN GENERAL CHEMISTRY FOR GENERAL SCIENCE CLASSES*

RALPH L. DANNLEY
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As a representative of the American Chemical Society and a university faculty member, I would like to emphasize the tremendous responsibility which has been thrust upon the general science teacher. Our government and industry have both expressed great concern regarding the shortage of trained scientists in the United States. We cannot tolerate this shortage in a world of unrest in which our military and economic security are dependent on our technical ability. The situation can be remedied only with your help.

The colleges and universities are prepared to offer the necessary professional training, but they must have students to train. An alarmingly small fraction of the college student body is now enrolled in science curricula. The selection of a major in science is usually made by an entering freshman student. Only rarely does a more advanced student transfer to science from a non-science field. Since the decision to be a scientist is made at the pre-college level, the responsibility rests entirely upon high school and general science teachers to interest students in careers in this field. One of the best tools you have to arouse such an interest is the lecture demonstration.

In order to arouse interest, a demonstration should be dramatic and entertaining. If possible, the equipment or chemicals used should be familiar in everyday life. Many such experiments have been described in the literature and others can be devised without much difficulty. In my short presentation I shall attempt to illustrate as many different sources of demonstrations as possible.

A lecture must have a theme if it is to be cohesive and today's experiments are selected to show the results chemists obtain by altering such factors as temperature, volume, etc. This may seem a very restricted field but, fortunately, a single demonstration may be used to illustrate several diverse subjects by emphasizing various aspects of the phenomenon. Therefore you can probably think of entirely different ways to use these experiments in your teaching.

Very unusual effects may be obtained by altering the temperatures of materials. The use of high temperatures is common in everyday life but extreme freezing conditions are less familiar and consequently more interesting. Either Dry Ice (−78°C.) or liquid nitrogen

* Presented to the General Science section of the Central Association of Science and Mathematics Teachers at Chicago, November 23, 1956.

($-196°$C.) may be used in the experiments I shall describe. A mush made of Dry Ice in acetone will produce a liquid cooling bath when needed. Liquid nitrogen because of its lower boiling point gives the same effects as Dry Ice in a shorter period of time.

The effect of extreme cold on live objects is dramatically illustrated by freezing a flower in liquid nitrogen. By immersing a flower in the cooling bath for a short time (15 seconds), the soft, pliable petals become fragile and glass-like and are readily crushed by the hand into tiny pieces. The drastic effects of liquid air are delayed somewhat, however, by the protective layer of nitrogen gas which is formed when the cold liquid touches a warm, living body. Therefore, you can pour liquid nitrogen over your hand for a second or two without harm if it is not in contact so long that the insulating layer of gas is no longer effective. One can even put liquid nitrogen in the mouth (*Great Caution*) if the liquid is kept moving in the mouth and retained for only a couple of seconds. Vigorous blowing expels the liquid nitrogen immediately. Care must also be taken not to touch the Dewar containing the liquid nitrogen to the lips or frostbite will result. This efficiency of a gas space as a thermal insulation is, of course, used in insulating homes, etc.

The behavior of rubber articles at low temperatures is important in the operation of vehicles in the Arctic or airplanes at high altitude. When a rubber ball is immersed in liquid nitrogen for a short time (20 seconds), it becomes so hard and brittle that instead of bouncing on a hard surface it breaks into many pieces. This unfavorable property of natural rubber has necessitated the development of the silicone rubbers whose properties remain relatively constant over an extended temperature range.

Liquid nitrogen or Dry Ice can also be used to illustrate the effects of volume change. When placed in a tightly corked tube, sufficient pressure is developed to shoot the cork across a room. For safe performance, the glass tube should be capable of withstanding high pressures. The Carius tube (any scientific supply house can provide) is perfect for this purpose.

If liquid nitrogen is placed in an ordinary toy steam engine, evaporation is so rapid that the engine runs rapidly and the whistle can be blown. The demonstration is of value in emphasizing that pressure and not heat is the immediate source of energy. In pouring the liquid nitrogen into the engine, a simple glass funnel may be used although it is advisable to wear gloves to protect the hands.

A change in volume is also an essential feature in the commercial synthesis of foamed plastics. By use of commercially available materials, a mixture of a polyester, toluene diisocyanate, soap, water and surfactant react to liberate a gas during polymerization so that a

rigid foamed plastic results. Either resilient or rigid products may be formed commercially by appropriate modifications to give foam-rubber-type materials or to provide, for example, a light-weight, rigid, foamed-in-place packing for inaccessible portions of airplane wings.

A change in volume always involves a change in concentration and this may affect the time of a chemical reaction. The famous iodine-clock experiment may be used to dramatically demonstrate this fact. Two stock solutions must be prepared. For one, 12 grams of soluble starch are dissolved in 600 cc. of boiling water, the solution allowed to cool, diluted to six liters and 2.5 gm. of sodium bisulfite and 30 cc. of 1 M. sulfuric acid added. The second solution consists of 12 gm. of potassium iodate in 6 liters of water. When 500 cc. portions of the two colorless solutions are mixed, nothing occurs for about 30 seconds, but at the end of this time, in about one second, the mixture turns a dark purple. If the two 500 cc. portions of the solutions are added to 150 cc. of water, the same phenomena is observed but the time interval before development of color is lengthened by about ten seconds. The time intervals are very exact and the demonstration can be made impressive by commanding the solutions to turn color at a specific second. Since the reaction is temperature dependent, however, it is advisable to make a trial experiment prior to a class presentation if an exact knowledge of the time is desired. This demonstration can be used to illustrate the effects of changes of time, volume or concentration. In fact, by adding ice, the reaction can be slowed down and the dependency on temperature shown. The experiment is really an example of the law of mass action if a more basic explanation is desired. This versatility of use is characteristic of many demonstrations.

Another experiment which illustrates variations of time is the use of an advancing flame front. Clamp a glass tube (about $\frac{1}{2}''$ diameter, $30''$ long) in an inclined position (about 30° from the horizontal) and place a small dam about two inches from the upper end. Putty or any other plastic material may be used for the dam as its only purpose is to retain a couple of drops at the top of the tube and prevent any liquid from draining downward. Place two drops of any volatile, combustible liquid (cyclohexane, lighter fluid, gasoline) behind the dam and, after about one-half minute, touch a match to the lower end of the tube. A flame front will travel slowly (about five seconds) up the tube. Liquid should not be allowed to overflow the dam, only vapors should traverse the tube. If the match is applied too soon, the vapor will not ignite. If too much time is allowed, an explosive mixture results and instead of a flame front, merely a mildly explosive "pop" will result. The necessary time is dependent on the liquid used, the

temperature, length of the tube, etc. and must be determined experimentally. By using two tubes of different lengths or two widely different solvents, the pre-ignition time interval is varied. Also, the longer the tube, the greater the length of time required for the flame-front to traverse the tube. This experiment can be used to illustrate controlled combustion (energy release) or the way in which volatile solvents ignite in starting fires.

Most energy changes, including the combustion just described, commonly occur with an evolution of heat. A chemical reaction in which energy is released as light, instead of heat, is less common. This experiment requires two solutions. One contains one gram of 3-aminophthalhydrazide and 100 cc. of 5% sodium hydroxide in 500 cc. of water. The second is prepared by placing 3 gm. of potassium ferricyanide and 100 cc. of 3% hydrogen peroxide in 500 cc. of water. When equal volumes of these two solutions are mixed, preferably in a dark room, they become luminous. This phenomena, called chemiluminescence, is most commonly observed in the firefly. Just as the firefly does not glow for long, similarly in this experiment the luminescence does not persist for long.

Change of color is important in many aspects of daily life. To the chemist, one of the common problems is the removal of objectionable colored impurities from colorless substances. The removal of color can be beautifully illustrated by the treatment of a copper sulfate solution with an ion exchange resin. When 50 cc. of saturated copper sulfate are allowed to trickle through 100 gm. of Dowex 50-X resin (50–100 mesh) in a glass tube, the blue color disappears and the effluent liquid is colorless. Actually the resin has been converted to a copper salt and colorless sodium ions are present in the effluent. The resin can be regenerated by adding 100 cc. of saturated sodium chloride solution. The resin returns to its original color and the effluent liquid is now blue. This is actually again a demonstration of the law of mass action. The phenomena is commonly encountered in everyday life in the use and regeneration of a water softener tank.

These experiments have been selected partially to show the variety of sources of materials for demonstrations. The chemiluminescence and iodine-clock experiments require only materials and equipment which are available from any scientific supply house. Liquid nitrogen, on the other hand, is more difficult to obtain. For educational purposes, one can probably arrange to get a supply not only from liquifaction plants but also from university or industrial research laboratories. In contrast, the foamed resin and ion exchange resin experiments required the use of industrial chemicals. Not only were these materials supplied free of charge for the experiments but, in addition, a complete set of directions were furnished for the resin formation.

This is characteristic of the cooperation given by the industrial organizations.

Several science teachers who majored in fields other than chemistry have asked me for suggestions as to sources for chemical demonstrations. It seems appropriate at this time to give some of the sources which are often overlooked.

The *Journal of Chemical Education* has devoted a portion of each of twenty-four successive issues to demonstrations in general chemistry. These articles have been collected and reprinted in a single booklet which will be given free to those subscribing to the journal for a year. Although this offer has officially expired, the editor of the *Journal of Chemical Education* has informed me that the booklet will still be sent to those who refer to this article when they subscribe.

The chemical industries are another source of chemical demonstrations. The industries are anxious to cooperate with the schools because of the general good will created, in order to increase the supply of future scientists, and as a method of institutional advertising. Therefore, you will find the sales managers and laboratory directors of nearby industrial organizations very willing to assist in planning experiments. Usually they will supply chemicals and loan equipment to aid in your work. Often they can utilize their own products and this adds interest, for the student usually has some familiarity with the materials manufactured in the area. The large national chemical organizations willingly supply samples of their products and booklets describing their use.

The American Chemical Society is very concerned with the problems of the science teacher. The local sections of the society have therefore organized committees to supply qualified chemists to help you in every way possible. If you will contact the nearest local sec- of the American Chemical Society I am sure that you will receive assistance in the preparation and presentation of experiments. In Cleveland, for example, the Society will even supply local speakers who give talks complete with demonstrations. If you do not know the address of the nearest local section of the American Chemical Society, contact the national office.

The American Chemical Society
1155 16th Street, N. W.
Washington 6, D. C.

I know not what the world may think, but to myself it seems that I have been but a child playing on the seashore; now finding some pebble rather more polished, and now some shell rather more variegated than another, while the immense ocean of truth extends itself, unexplored, before me.

—Sir Isaac Newton

COMMUNICATIONS FALL OUT

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"Fall out. . . . You won't find that phrase in the dictionary. But you'll find it talked about everywhere these days," says United Press writer, George J. Marder. But he doesn't define it. One who is less eligible ventures to say, "Fall out is a secondary, but menacing, by-product of a performance initiated for another purpose."

Most experienced teachers recall many unexpected responses to their instruction (i.e. communications.) For instance, the well known boner, "The equator is a menagerie lion running around the earth" was a pupil's version of what a teacher had said. Successful teaching may be said to have few such aborted outcomes.

For scientists there is the added responsibility of helping the adult community keep informed about the new as it is found by research. Galileo's failure at that point comes to mind. "For putting belief to the test of experiment and founding conclusions upon observation (his) reward was imprisonment . . . and a broken heart."[1] He was so treated because he had failed to adequately share his progress with his critics and his communications had not meant to them what it meant to him. His critics had caught a *fall out.*

Modern investigators have become properly attentive to this aspect of their work. So there are, now, specially trained science reporters. The science magazines, *Science News Letter*, *The Scientific American* and *The Scientific Monthly* are written and edited with the non-technical public in mind. More recently radio and television have increasingly programmed science subjects. Generally authors of such features have sought and used the collaboration of competent scientists.

However, within the past ten years the achievements of nuclear science have placed such sensational findings in the hands of the reporters that they have become impatient with their more cautious scientific team-mates. Result: many of their stories have become suffused by superlatives that have created excited rather than informed readers. After that first spasm they took a look behind the findings and met the discoverers. In their effort to make this report on personnel as newsworthy as that which had gone before, resort was to a stress of eccentricities of the scientists rather than a proper regard for the industry, persistence and resourcefulness of those men and women. Present concern is, what would such an account do for its readers?

[1] R. A. Gregory, "Discovery," 1925, p. 2. Macmillan Company, New York.

President Whitney Griswold of Yale has said,[2] of the scholarly individual, "(there is too commonly) the idea . . . (that he is) a being apart from his fellowmen, a snob, a mystic . . . a member (of the community) unattainable . . . (by) ordinary mortals." If people think of the scientists so, may it conceivably stem somewhat from the failure of those reporters to get correct information to their readers?

The growing volume of science in the news, it would seem, has attracted a host of camp followers. In addition to the non-technical magazines there is a mounting output of books for the same readers. These often try to popularize their subjects as a sort of magic for the moderns. Luncheon speakers dilate on gadgets as indices of progress. Television and radio commercials, phrased in the words of science, huckster wares and health helps and even the unmentionables. To further confuse the thrill-hungry public, science fiction is on the increase. Even the comics are cutting in on the show. Certainly many media of communications are publicizing science. However, there are those who wonder if the results may be more properly measured by an "emotional thermometer" than by an intelligence test.

Doctor Bronowski leaves little to doubt as to his estimate.[3] "To think of science as a set of special tricks, to see the scientist as a manipulator of outlandish skills . . . this is the root of the poison mandrake which flourishes in comic strips.

"There is no more threatening and no more degrading doctrine than the fancy that somehow we may shelve responsibility for making the decisions of our society by passing it to a few scientists armored with a special magic." Fall out from comics?

What of science fiction? *Newsweek* reports,[4] "Almost overnight, after the first (atomic) bomb was dropped, adults replaced adolescents as the most rabid (readers) of science fiction." Arthur J. Barren, an author for *The Bulletin of the Atomic Scientists*, assumes that many of those adult readers are scientists when he says, "Real peace in the world would stop (this escapeism) short; as would the bestowal of 'real status' on the scientists and engineers."

An evening with a dinner club dates an internationally known interpreter of science as speaker. His subject is "Science Leads the Way." His audience hears him "pave the way" with blurbs labelling laboratories as "birthplaces of the future" and "science and progress as inseparably linked." The uncritical auditors are in no way deterred from an implicit belief that "the scientists is in his laboratory, all's well with the world."

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[2] *Saturday Review*, November 10, 1956.

[3] *The Nation*, December 29, 1956.

[4] March 3, 1956.

If that dinner's coffee prevents sleep television will take up the tale and add its superlatives. A new gadget is more to be desired if it is "electronic"; a pill is more dependable if it is a mixture "like a doctor's prescription"; gasoline is enormously more powerful if it has TCP in it. If it comes from the laboratory; if it's a product of research or, as a last resort, have it in a testtube in the hands of a white-coated publicist and sales are assured! Creators of commercials, it would seem, fully agree with the court reporter's[5] definition of evidence. He says, "It is anything that will lead your hearer to believe what you want him to believe." But do such blurbs lead to belief? One wonders just what sort of an estimate of science or the scientist a straight-thinking non-scientist gets from an evening before these American commercials?

Books and magazines, with nothing to sell but ideas, should show a reasonable restraint. Yet even these, in many instances, have the same mental pap. Titles frequently appeal to extravagant expectations. Some impel one to think they consciously cater to the indefinite by their use of: amazing, fabulous, marvelous, spectacular, mysterious and incredible. A book list released in *The Scientific Monthly*[5a] has fourteen of its 186 titles using such wizard-words. The favorites are "miracle" and "magic." Others appearing are: amazing, fascinating, wonderful, marvelous and romance. The intent, no doubt, is to win attention until inherent interest may take hold. There are, however, hazards of distorted attitudes in such phrasing.

We hear much said of current inadequate supply of scientists and engineers. Whether the youth see fit to meet this disturbing shortage is, in part, dependent upon their estimate of what the scientist is like and what a scientific vocation demands. A recent poll of high school students[6] found one out of every four who thought the scientists "more than a little odd" and that "the scientist would be willing to sacrifice the welfare of others to further his own interests." One out of every ten of them said "there is something wicked about scientists" and that they "are likely not to be honest." An Oklahoma survey of high school juniors reported that some of them characterized the scientists as: "long hairs in sweat shirts," "squares working in musty laboratories" or "evil geniuses thinking up ways to torture people." The query arises, Are these ideas original with these young people or do they have them from communications that have missed their intended import?

President Griswold[7] considers that the Intellectual (including the

[5] A. Rose, "So You Want to Be a Witness?" 1926, p. 26. *New York Institute Press.*

[5a] December, 1956, pp. 301–305.

[6] H. A. Remmers, "Physical Science Aptitude and Attitudes toward Occupations," Poll 45. Purdue University, Lafayette, Indiana. 1956, p. 3.

[7] *Saturday Review, ibid.*

scientist), as well as the public, seems ready to accept the status of "a being apart from his fellowmen." It is President Griswold's judgement that this attitude is a "delusion" and a basic factor in America's present shortage of college teachers." Is it possible that the scientists have acquired that "delusion" by accepting the public's aborted estimate founded upon what may be called "communications fall out"?

That which has been cited above does not constitute proof, of course. There are implications in it, however, that should warrant concerned attention. Just how a classroom teacher may implement that concern may be in order. The following proposals do not exhaust the possibilities. They may serve as starters and in turn stimulate other better leads.

1. First let us as teachers take a searchingly critical look at our own program of communications. Do we smother our exposition by a surfeit of superlatives? Do we by-pass the industry and perseverance of the Nobel prize winners by the frequent use of such phrases as: "at once," "immediately," "suddenly" thus implying an almost magical readiness of achievement? Have we, in a mistaken effort to get student attention, been cartooning these men and women in their laboratories? Has our choice of visual-aids over-stressed industrial gadgets to the neglect of more significant mentally challenging aspects of science?

2. Have we exercised as much discernment in the selection of books for our students as we have in the choice of equipment for their laboratories? A book that is to have an inherent appeal must be more than a vendor of miracles further mystified by a smoke-screen of superlatives.

3. Is it in order to further propose some specific attention to current propaganda-type sales talk? Is it possible that an excessive use of "merit by association," "brain-wash by repetition" and "jazzed doggerel" may lead to inability to sense the irrational? It may be trite to say there are two aspects of this super-sales technique to watch: the half-truths used as if "that is the last word" and the tricky logic that superficially appears plausible. It may be helpful to make use of listings of propaganda techniques found in sociology[8] texts or other references. There are also books[9] on "straight thinking" that are helpful in spotting the quirks of the tricky logic in those propaganda patterns.

4. Has emphasis on "tested evidence," so often in our shop talk a decade ago, gone out of fashion? It was then quite in order to justify laboratory costs by its provision, in a unique way, for practice in seek-

[8] Chester Hunt and Collaborators, *Sociology*, 1954, p. 111. Alemars, Manila, Philippine Islands.

[9] Stuart Chase, "Guides to Straight Thinking," 1956. Harpers Brothers, N. Y.

ing and using "objective evidence."[10,11] Is it presumptuous to think some skill in that practice might now have merit in identifying and properly reacting to these communication fall outs?

That which has been said is not intended to totally damn the various media of communications. Interest upon the part of the learner is undoubtedly a major means of motivation. Personalization and confronting the learner with that which is challenging and even, at times, by the bizarre, may be in order. In other words this does not discredit novelty of method but rather calls for a continuous check of the method used to make sure it has not brought a teaching outcome not planned by the teacher. Successful instruction has always and still follows carefully formulated objectives. It demands that objectives control and limit methods used. The methods should never steal the show. May that be partly responsible for Communications Fall Out?

[10] "Laboratory Evidence," *The Science Teacher*, September, 1953, pp. 170–171.
[11] "Evidence Awareness," *The Science Teacher*, March, 1955, pp. 77–80.

EFFECTS OF SMOKING ON CANCER

A person's smoking habits are a "mileage ticket on his life," Dr. Alton Ochsner, head of the department of surgery at Tulane University Medical School, said. Dr. Ochsner predicted that life insurance companies will soon grant lower premium rates to persons who do not smoke because they live longer.

Studies by the American Cancer Society show that the incidence of persons contracting lung cancer is 400 per cent higher among smokers than non-smokers, Dr. Ochsner said. But lung cancer does not seem to be the only disease linked with smoking, he added. These same studies show that the incidence of heart disease is 95 per cent higher and the rate of all cancers is 156 per cent higher among persons who smoke, he said. The number of cases of lung cancer has jumped markedly in recent years, he said. In New York state alone lung cancer among men has increased 468 per cent during the past 20 years while all other cancers have increased only 2 per cent. Among women in New York lung cancer has increased 68 per cent while all other cancers have decreased 15 per cent. Lung cancer is most often linked with cigarette smoking, while smoking a pipe or cigars may cause cancer of the lip and tongue, Dr. Ochsner said. A man 50 years old who has smoked one package of cigarettes a day for the past 25 years has a 10 times greater chance of developing lung cancer than a man who has never smoked. The incidence of lung cancer directly parallels the rate of smoking, he said. A person who smokes six cigarettes a day, he said, is more likely to develop lung cancer than a person who smokes only three cigarettes, and a person who smokes a full package a day is more likely to develop cancer than the person who smokes only six. "Of course, the person who does not smoke at all is least likely to develop lung cancer," the surgeon said.

Cancer of the lung is most prevelant in persons between the ages of 50 and 70 Dr. Ochsner said. This type of cancer usually takes 25 years to develop and produce a noticeable effect, he explained. "If the cancer-causing agent in tobacco—called "3,4-benzpyrene"—is not willingly removed by the tobacco industry, tobacco may come under the same kind of federal control which now directs the use of morphine," Dr. Ochsner speculated. "But while morphine does have a medical advantage because it controls pain, there is absolutely no advantage in the use of tobacco other than for pleasure."

THE CHALLENGE OF PRACTICAL APPLICATIONS[1]

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As I examined the title, "The Challenge of Practical Applications," I could not, at first, decide whether to consider it to mean "The Challenge of Practical Applications to Students" or "The Challenge of Practical Applications to Teachers." Finally, I decided to interpret it to mean "The Challenge of Finding Practical Applications." This way, the title is broad enough to include both of the former topics. For, indeed, the finding of practical applications is a challenge in itself to the instructor, and only those applications must be chosen which will be a challenge to the student.

Let us consider first of all just when a practical application is a challenge to the student. It seems to me the first requirement must be that the application be a *real one*. Although there are many real practical applications in modern text books, problems are much more real to the student if the teacher supplements the text book treatment of an application with live data he has assembled or with information collected by the students.

Students should be made aware of the *World Alamnac* and *The Annual Statistical Abstract of the United States* as sources of practical applications. Students should also be taught to read newspapers and magazines with an eye peeled for practical applications of mathematics in daily life. They should consult business and professional people, many of whom will be their own parents, as sources of practical applications of the mathematics they are studying or will need to study.

A second requirement of a practical application if it is to be challenging to the student is that it be within reasonable comprehension of the student. Many of the applications of mathematics arise out of situations which students of elementary mathematics have no basis for understanding. These applications come from the research laboratory or from the technical work of engineers. When the instructor tries to present such applications in mathematics classes it is often to confuse many of the students more than to stimulate them. Some instructors feel that it takes more time and effort to explain the setting of the applications and therefore their meanings than the values derived from them. These same instructors feel that the usual "age" problems, "clock" problems, "mixture" problems and "pursuit" problems that have been appearing in algebra texts for centuries would have disappeared long ago if equally easily understood real, modern applications could have been found as substitutes.

[1] This paper was presented at the Summer Meeting of The National Council of Teachers of Mathematics at U.C.L.A., Los Angeles, California, August 22, 1956.

Instructors should encourage individual pupils who have special interest in particular kinds of applications to pursue these interests independently of the rest of the class and bring the mathematics problems which arise from these interests to class for discussion. In this way the instructor will have data from a wide range of interests which he can use in creating real practical applications for his classes.

In selecting practical applications which are challenging to students, some regard must be given to the maturity and interest of the students. Last semester I taught a freshman course in College Algebra at Harris Teachers College, St. Louis. The students in the class ranged in age from 17 to 20 years of age. The majority of them were just graduated from high school. I also taught a night school class in the same subject at Washington University, St. Louis. The students in this class were primarily men and women from the industrial plants of Metropolitan St. Louis. This group of students brought in many practical applications from their various jobs. These applications ranged from simple arithmetic problems to problems that were beyond the scope of the course and the mathematical maturity of the students. These applications were discussed at great length. The time spent on such discussion was very worthwhile to the class. If the same applications had been discussed in the day school class, probably the only emotion stimulated would have been boredom.

In presenting a practical application used in mathematics to a class—even though it is presented in the field from which it comes—the instructor must point out the mathematics involved. If a practical application is to be a challenge to the mathematics student, the mathematics must stand out as such.

Even if the practical applications presented to our classes meet all of the above requirements, the challenge is lost unless in the evaluation of the learning of the students we test their ability to solve applied problems. Too often we emphasize practical applications in our teachings and use them to motivate interest, but when we test we include only mechanical problems. If we don't use practical applications on our tests, we will find that the students will be much less concerned about them than if they are included in the testing process.

Now, the time has come to discuss the "where" in finding practical applications which will be challenging to the student. If you are looking for your problems already made up for you the easiest place to find them is in textbooks, particularly textbooks with such titles as *Business Mathematics*, *Aviation Mathematics*, *Mathematics for Engineers*, etc.

If you are looking for data from which to construct your own problems the references are endless. *The World Almanac* has a wealth of material from which you can construct practical problems. A few

easily accessible references are: ***Statistical Abstract of the United States;*** Newspapers; Magazines such as ***Business Week, The Kiplinger Magazine,*** Engineering Publications, etc.; ***Road Maps of Industry; Publications of Industry;*** Mathematical Journals; Science Books; Physics Books; ***Source Book of Mathematical Applications,*** 17th Year Book, National Council of Teachers of Mathematics. Many industrial plants are most cooperative in aiding instructors who desire to present real practical applications to their classes.

Even though many instructors know where to find data with which to construct "real" problems for their classes, most of them find it difficult to construct the problems themselves. For the past several years I have had the privilege of editing the Problem Section of SCHOOL SCIENCE AND MATHEMATICS. During this time I have found that many people are inclined to solve the problems which are published for solution, but few are inclined to create them and submit them for solution. For every problem published many solutions are submitted, but very few problems are submitted for solution. Of the problems submitted for solution less than one-fourth are original. Most are difficult or tricky problems that have appeared in texts, magazines, or newspapers.

Because so many instructors either dislike creating original practical applications or find it difficult to do so, I have assembled a few problems that have been constructed from data available to every instructor. Each of these problems illustrates one or more of the points discussed above for making practical applications challenging to students.

ILLUSTRATIVE EXAMPLE 1

The maker of an oscillating lawn sprinkler (Fig. 1.) labels each size and setting with the length of the rectangular area which its spray will cover. This length may be approximated by considering only one of the jets and by treating it as one would any small, slow-moving projectile such as a stone shot from a slingshot.

1. What kind of curve is each spray of water?

2. The equation of such curves are $x=at$, $y=16t^2+bt$, where a and b depend on the nozzle velocity and its angle of elevation, and t is the number of seconds after the projectile is released.

After how many seconds does a projectile released hit the level ground if its path is given by the above equations and $a=30$ and $b=40$?

3. For the projectile in Ex. 2, at the end of how many seconds is the projectile 32 feet off the ground?

4. When does the projectile in Ex. 2 reach its maximum height?

ILLUSTRATIVE EXAMPLE 2

The data On Table I give certain properties of the standard atmosphere. The data in this table are used by an aircraft company in designing new aircraft.

TABLE I

PROPERTIES OF THE STANDARD ATMOSPHERE

(Reference NACA TN 3182)
ICAO STANDARD DAY

Altitude (Ft.)	Pressure	
	(Lb./Ft.²)	(In. Hg)
10,000	1455	20.58
11,000	1400	19.79
12,000	1346	19.03
13,000	1294	18.29
14,000	1243	17.58
15,000	1194	16.89
16,000	1147	16.22
17,000	1101	15.57
18,000	1057	14.94
19,000	1014	14.34
20,000	972.5	13.75
21,000	932.4	13.18
22,000	893.7	12.64
23,000	856.3	12.11
24,000	820.2	11.60
25,000	785.3	11.10
26,000	751.6	10.63
27,000	719.1	10.17
28,000	687.8	9.725
29,000	657.6	9.297
30,000	628.4	8.885
31,000	600.3	8.488
32,000	573.3	8.106
33,000	547.2	7.737
34,000	522.1	7.382
35,000	498.0	7.041
36,000	474.7	6.712
37,000	452.4	6.397
38,000	431.2	6.097
39,000	411.0	5.811
40,000	391.7	5.538

1. Study the data in the table. Make a graph plotting altitude vs pressure in pounds per square foot.

2. From the graph in Ex. 1 we see that the pressure, P, is a function of the altitude, A. Write this using functional notation.

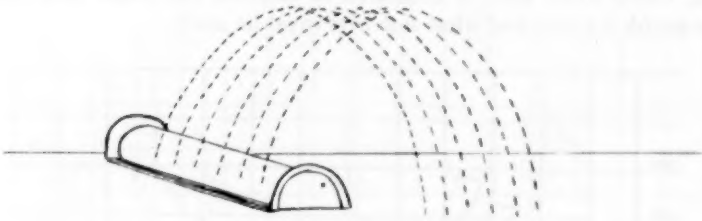


FIG. 1

3. Is the function in Ex. 1 and 2 decreasing or increasing?

ILLUSTRATIVE EXAMPLE 3

Ordinary commercial compression and extension springs are subject to four major variables which affect the load: 1) wire diameter; 2) coil diameter; 3) number of active coils; 4) deflection from free length. Mathematical relationships are graphed to show the relative change due to the magnitude of these variables. (See graphs labeled 3-a and 3-b.)

The graphs pictured below are for the first two variables mentioned.

Variable Number 1: Wire Diameter

Commercial wire is subject to mill tolerance on diameter, and this variation has a major effect in producing variation in loads since the load deflection ratio or rate per inch varies directly as the fourth power of the wire diameter.

This can be illustrated by considering a commercial tolerance on 0.010 music wire of ± 0.0003 and a commercial tolerance of 0.250 valve spring quality steel of ± 0.002. In the case of the 0.010 wire a variation to 0.0103 the load would be increased approximately 9% whereas in the case of the 0.250 wire a variation of 0.252 the load would be increased approximately $3\frac{1}{4}$%.

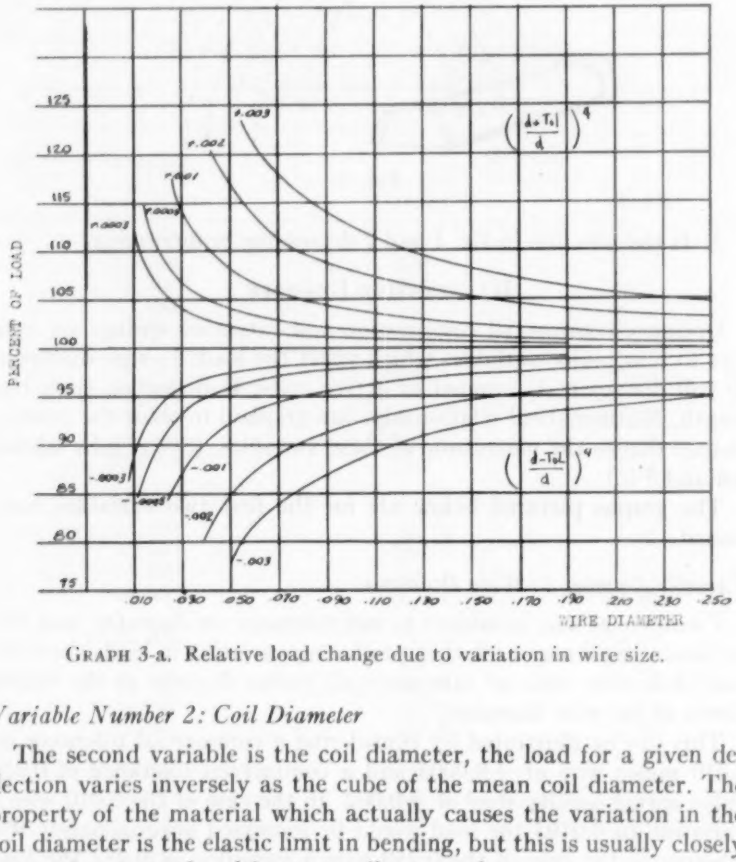
The above paragraph shows the relative effects on the load of the commercial tolerances as applied to large and small wire sizes. Consideration can now be given to graph 3-a[2] which illustrates that the same plus and minus tolerance on a given size will produce a slightly different change in the load. This is due to the progression of the mathematical function.

1. Using wire size 0.030 a variation of $+0.0005$ would cause a

[2] *The Mainspring*, Associated Spring Corp., Bristol, Conn., June 1956.

change in the load of approximately what per cent of the mean load? What change in the mean load will a minus variation of 0.0005 cause?

2. Using 0.062 wire, it is desired to increase the mean load 20%. Use graph 3-a and find what size wire must be used.



GRAPH 3-a. Relative load change due to variation in wire size.

Variable Number 2: Coil Diameter

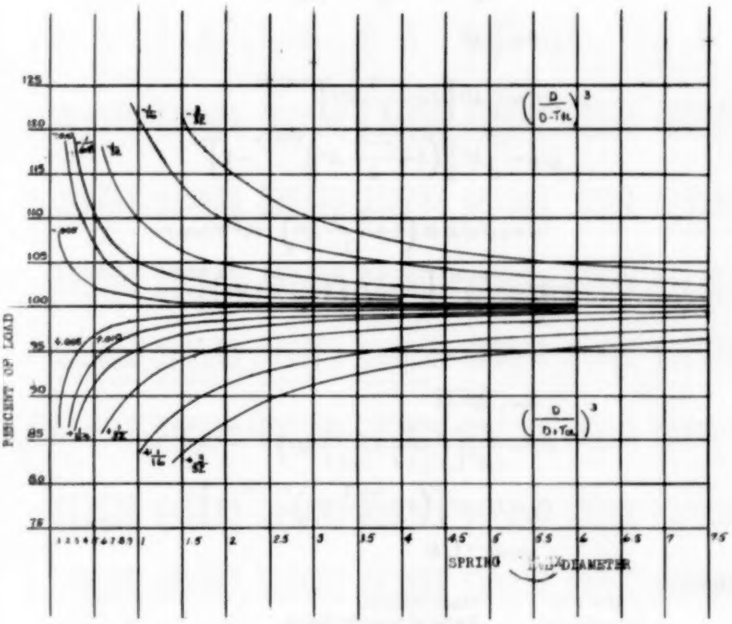
The second variable is the coil diameter, the load for a given deflection varies inversely as the cube of the mean coil diameter. The property of the material which actually causes the variation in the coil diameter is the elastic limit in bending, but this is usually closely proportionate to the ultimate tensile strength.

Even though the natural tendency is for a greater variation for a greater index $[D/d]$, the effectiveness of specific variation is reduced by the increase in index. This is true, because for a certain wire size, the increase in coil diameter increases the index and decreases the span of load variation as shown in graph 3-b.

3. Using a mean spring diameter of 3 inches, a variation of $+1/16$ inch would cause a change in load of what per cent of the mean calculated load? A variation of $-1/16$ inch would cause a change in load of what per cent of the mean calculated load?

4. Using a mean coil diameter of 2 inches, a variation of $+3/32$

inch would cause a change in load of what per cent of the mean calculated load? What change in load would a $-3/32$ inch cause?



GRAPH 3-b. Relative load change due to variation in diameter.

ILLUSTRATIVE EXAMPLE 4

The data below give a summary of equations and nomenclature used in the aircraft industry.[3]

[3] McDonnell Aircraft Corp., St. Louis, Mo.

TABLE II

EQUATIONS AND NOMENCLATURE

$$P/H=\left(1+\frac{\gamma-1}{2}M^2\right)^{-\gamma/\gamma-1}$$

$$T/T_t=\left(1+\frac{\gamma-1}{2}M^2\right)^{-1}$$

$$a/a_t=\left(1+\frac{\gamma-1}{2}M^2\right)^{-1/2}$$

$$\rho/\rho_t=\left(1+\frac{\gamma-1}{2}M^2\right)^{-1/(\gamma-1)}$$

$$A^*/A=\frac{1}{M}\left[\frac{2\left(1+\frac{\gamma-1}{2}M^2\right)}{\gamma+1}\right]^{\gamma+1/[2(\gamma-1)]}$$

$$V/V^* = M\left[\frac{\gamma+1}{2\left(1+\frac{\gamma-1}{2}M^2\right)}\right]^{1/2}$$

$$q/P = \frac{\gamma}{2}M^2$$

$$q/H = \frac{\gamma}{2}M^2\left[1+\frac{\gamma-1}{2}M^2\right]^{-\gamma/(\gamma-1)}$$

$$q/q_c = \frac{\gamma}{2}M^2\left[\left(1+\frac{\gamma-1}{2}M^2\right)^{\gamma/(\gamma-1)}-1\right]^{-1}$$

$$°m = g\sqrt{\gamma/R}\,M\left(1+\frac{\gamma-1}{2}M^2\right)^{1/2}(\sqrt{°R}/\text{sec.})$$

$$F/F^* = \frac{1+\gamma M^2}{M}\left[2(\gamma+1)\left(1+\frac{\gamma-1}{2}M^2\right)\right]^{-1/2}$$

$$\alpha = \sqrt{1-M^2}$$

$$\beta = \sqrt{M^2-1}$$

$$C_p^* = \frac{2}{\gamma M^2}\left[\left(\frac{2}{\gamma+I}+\frac{\gamma-1}{\gamma+1}M^2\right)^{\gamma/(\gamma-1)}-1\right]$$

$$C_{p_t} = 2/\gamma M^2\left[\left(1+\frac{\gamma-1}{2}M^2\right)^{\gamma/(\gamma-1)}-1\right]$$

$$\mu = \sin^{-1} 1/M$$

Where:

$M = V/a$	Mach Number
$\gamma = C_p/C_v$	Ratio of Specific Heats
C_p	Specific Heat at Constant Pressure
C_v	Specific Heat at Constant Pressure
P	Static Pressure
$\delta = P_{alt}/P_{S.L.}$	Static Pressure Ratio
H	Total Pressure
Mach Number	Ratio of true airspeed to speed of sound
T	Temperature
$a = \sqrt{\gamma RT}$	Velocity of Sound
ρ	Mass Density
A	Area
V	Velocity
$q = \frac{1}{2}\rho V^2$	Dynamic Pressure
$q_c = H - P$	Difference between Total & Static Pressure
$°m = WT_t^{1/2}/PA$	Mass Flow Parameter
W	Mass Flow
$R = P/\rho T$	Perfect Gas Constant
g	Gravitational Constant
$°R$	Degrees Rankine
F	Impulse Function
α	Glauert-Prandtl Subsonic Correction Factor
β	Ackeret Supersonic Correction Factor
$C_p = (P - P_0)/q_0$	Pressure Coefficient
μ	Mach Angle

and the Subscripts Represent:

$(\ )_t$	Stagnation Conditions
$(\ )^*$	Critical Conditions—(M 1)
$(\ )_0$	Free Stream Conditions

TABLE III

M	P/H	T/T_t	a/a_t	ϵ/ϵ_t	A^*/A	V/V^*	q/p	q/H	q/q_c	$\frac{^\circ m}{\sqrt{^\circ R}/\text{sec.}}$	F/F^*	$\alpha;\ \beta$	$1/\alpha;\ 1/\beta$	$-C_p^*$	C_{pt}	μ
.75	.6886	.8989	.9481	.7660	.9412	.7789	.3938	.2711	.8706	.7269	1.0314	.6614	1.5119	.5912	1.1487	
.76	.6821	.8964	.9468	.7609	.9461	.7883	.4043	.2758	.8674	.7376	1.0284	.6499	1.5386	.5577		
.77	.6756	.8940	.9455	.7557	.9507	.7975	.4150	.2804	.8642	.7483	1.0257	.6380	1.5673	.5253		
.775	.6723	.8928	.9449	.7531	.9529	.8022	.4204	.2827	.8626	.7537	1.0244	.6320	1.5824	.5095	1.1593	
.78	.6690	.8915	.9442	.7505	.9551	.8068	.4259	.2849	.8610	.7591	1.0231	.6258	1.5980	.4940		
.79	.6625	.8890	.9429	.7452	.9592	.8160	.4369	.2894	.8577	.7699	1.0208	.6131	1.6310	.4639		
.80	.6560	.8865	.9416	.7400	.9632	.8251	.4480	.2939	.8544	.7808	1.0185	.6000	1.6667	.4346	1.1704	
.81	.6495	.8840	.9402	.7347	.9669	.8343	.4593	.2983	.8511	.7916	1.0165	.5864	1.7052	.4064		
.82	.6430	.8815	.9389	.7295	.9704	.8433	.4707	.3027	.8478	.8026	1.0146	.5724	1.7471	.3791		
.825	.6398	.8802	.9382	.7268	.9721	.8479	.4764	.3048	.8461	.8081	1.0137	.5651	1.7695	.3657	1.1819	
.83	.6365	.8789	.9375	.7242	.9737	.8524	.4822	.3069	.8444	.8135	1.0128	.5578	1.7929	.3526		
.84	.6300	.8763	.9361	.7189	.9769	.8614	.4939	.3112	.8410	.8246	1.0112	.5426	1.8430	.3269		
.85	.6235	.8737	.9347	.7136	.9797	.8704	.5058	.3153	.8376	.8356	1.0097	.5268	1.8983	.3020	1.1939	
.86	.6170	.8711	.9333	.7083	.9824	.8793	.5177	.3195	.8341	.8467	1.0083	.5103	1.9597	.2778		
.87	.6106	.8685	.9319	.7030	.9849	.8882	.5298	.3235	.8307	.8578	1.0070	.4931	2.0282	.2544		
.875	.6073	.8672	.9312	.7003	.9861	.8926	.5359	.3255	.8290	.8634	1.0065	.4841	2.0656	.2429	1.2063	
.88	.6041	.8659	.9305	.6977	.9872	.8970	.5421	.3275	.8272	.8690	1.0059	.4750	2.1054	.2316		
.89	.5977	.8632	.9291	.6924	.9893	.9058	.5545	.3314	.8237	.8802	1.0049	.4560	2.1932	.2094		
.90	.5913	.8606	.9277	.6870	.9912	.9146	.5670	.3352	.8202	.8915	1.0040	.4359	2.2942	.18787	1.2192	
.91	.5849	.8579	.9262	.6817	.9929	.9233	.5797	.3390	.8167	.9028	1.0032	.4146	2.4119	.16689		
.92	.5785	.8552	.9248	.6764	.9944	.9320	.5925	.3427	.8131	.9142	1.0025	.3919	2.5516	.14647		
.925	.5753	.8539	.9241	.6737	.9951	.9363	.5989	.3446	.8113	.9198	1.0022	.3800	2.6318	.13644	1.2326	
.93	.5721	.8525	.9233	.6711	.9958	.9407	.6054	.3464	.8095	.9256	1.0019	.3676	2.7206	.12654		
.94	.5658	.8498	.9218	.6658	.9969	.9493	.6185	.3499	.8059	.9370	1.0014	.3412	2.9311	.10716		
.95	.5595	.8471	.9204	.6604	.9979	.9578	.6318	.3534	.8023	.9485	1.0009	.3122	3.3026	.08822	1.2464	
.96	.5532	.8444	.9189	.6551	.9986	.9663	.6451	.3569	.7987	.9600	1.0006	.2800	3.5714	.06975		
.97	.4569	.8416	.9174	.6498	.9992	.9748	.6586	.3602	.7950	.9716	1.0003	.2431	4.1134	.05173		
.975	.5438	.8402	.9167	.6472	.9995	.9790	.6654	.3619	.7932	.9774	1.0002	.2222	4.5003	.04283	1.2608	
.98	.5407	.8389	.9159	.6445	.9997	.9833	.6723	.3635	.7913	.9832	1.0001	.1990	5.0252	.03408		
.99	.5345	.8361	.9144	.6392	.9999	.9916	.6861	.3667	.7876	.9949	1.0000	.1411	7.0888	.01685		
1.00	.5283	.8333	.9129	.6339	1.0000	1.0000	.7000	.3698	.7839	1.0066	1.0000	.0000		.00000	1.2756	90.00
1.01	.5221	.8306	.9113	.6287	.9999	1.0083	.7141	.3728	.7802	1.0184	1.0000	.1418	7.0535	−.01650		81.93
1.02	.5160	.8278	.9098	.6234	.9997	1.0166	.7283	.3758	.7765	1.0302	1.0001	.2010	4.9752	−.03262		78.64
1.03	.5099	.8250	.9083	.6181	.9993	1.0248	.7426	.3787	.7728	1.0421	1.0003	.2468	4.0522	−.04842		76.14
1.04	.5039	.8222	.9067	.6129	.9987	1.0330	.7571	.3815	.7690	1.0540	1.0005	.2857	3.5007	−.06390		74.06
1.05	.4979	.8193	.9052	.6077	.9980	1.0411	.7718	.3842	.7652	1.0659	1.0008	.3202	3.1235	−.07914	1.3068	72.25
1.06	.4919	.8165	.9036	.6024	.9971	1.0492	.7965	.3869	.7614	1.0779	1.0012	.3516	2.8444	−.09406		70.63
1.07	.4860	.8137	.9020	.5972	.9961	1.0573	.8014	.3895	.7576	1.0900	1.0016	.3807	2.6270	−.10869		69.16
1.075	.4830	.8123	.9013	.5946	.9955	1.0613	.8089	.3907	.7557	1.0960	1.0018	.3945	2.5349	−.11589	1.3232	68.44
1.08	.4800	.8108	.9005	.5920	.9949	1.0653	.8165	.3920	.7738	1.1021	1.0020	.4079	2.4514	−.12305		67.81
1.09	.4742	.8080	.8989	.5869	.9936	1.0733	.8317	.3944	.7500	1.1143	1.0025	.4337	2.3057	−.13718		66.55

1. If $M=0.75$, find the value of α.
2. If $M=1.09$, determine the value of μ.
3. If $M=0.79$, determine V/V^*.
4. If $M=0.875$, determine A^*/A.
5. Table III shows that M must be 1.0000 before μ is defined. Using the equation $\mu=\sin^{-1} 1/M$ explain why μ is not defined for values of M less than 1.0000.
6. In Table II, values of α and β are given in the same column. For what values of M do you use the formula for β? For what values of M do you use the formula for α?
7. Write the formula for q/H without using negative exponents.
8. Solve for P/H in terms of T and T_e.

A NEW EDUCATIONAL DIRECTORY OF HIGHER EDUCATION

The Office of Education has released its new annual "Education Directory Part 3: Higher Education" which lists a total of 1,886 institutions.

Included for the first time in this edition is the calendar system on which each institution operates—semesters, quarters, or other units.

The 1956–57 listing is larger by 31 than last year's total and 187 more than the 1940 figure. The new directory includes institutions offering at least 2-year college-level programs and meeting certain other standards.

The largest number of institutions of higher learning is reported for New York State—153. Next in order are: California, 138; Pennsylvania, 117; Illinois, 102; Texas, 96; Massachusetts, 77; Wisconsin, 63; Ohio, 62; Michigan and North Carolina, 55 each; Missouri, 53; and Iowa, 50.

More than one-third (744 of the 1,886 institutions) are under denominational control. This includes 474 Protestant colleges and universities; 265 Roman Catholic; and 5 Jewish. Under private control are 481; public control, 661, including 282 under district or city; 369 under State, and 10 under Federal control.

Coeducational institutions number 1,414. Of the remainder, 223 are for men and 249 for women.

The Ph.D. or equivalent degree is granted by 191 of the institutions. Over 500 institutions provide programs of less than 4 years.

The directory was prepared by Theresa Birch Wilkins, of the Division of Higher Education, Office of Education. It can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, C. D., at 65 cents a copy.

MORE TRAINING WITH SCIENTIFIC EQUIPMENT CITED AS NEED IN STUDY OF PHYSICS

Industry would like to see physics students receive more applied training in the use of scientific equipment.

This was one of the conclusions in a report made by Dr. George C. Higgins of Kodak Research Laboratories at a symposium of the American Association of Physics Teachers at the Hotel New Yorker in New York City. Suggestions were given for improving the quality and effectiveness of introductory physics courses. These included ideas developed in a study made last September at Carleton College, Northfield, Minn.

Dr. Higgins' talk was on "Implications for the Training of Scientists for Industry." Among other points, he emphasized the need for more graduates in physics at the B.S. degree level as well as the generally recognized demand for physicists who have obtained the Ph.D.

THE CHALLENGE TO HIGH SCHOOL SCIENCE TEACHERS

A. H. Drummond, Jr.
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In recent months widespread publicity has been given to a problem basic to the survival of our western civilization. This problem is the "technical race" between the Soviet Union and the West. Experts assert that Soviet education in the sciences and mathematics is rapidly surpassing our own production. There is fear that this trend can be harmful to our future peace and security.

Unfortunately, the problem is far more extensive than is usually indicated. Not only are we falling behind compared with the Soviet Union, but we fall short of our own needs of scientifically trained manpower. There is increasing demand for chemists, physicists, and engineers. But apparently the youth of this country is not responding to the demand. The deeper problem here is the reasons behind this lack of response to a great need. None of us will take the position that our children are not capable of being trained in the sciences. All teachers of science can point to many students who have great potential, but know that few of them will ever reach a high degree of achievement in scientific fields. Why? Is it the fault of the student, or is our educational system at fault?

An instructor in college physics said to me recently that in his school the majority of freshmen are not permitted to enroll in elementary physics because too many freshmen fail. Only those with very superior ability are allowed to register for the course. This solves a curricular problem, to be sure, but hinders the school's opportunity to make a significant contribution to the field of physics. Instructors in college chemistry have similar complaints. The largest single complaint is that many students are not capable of using basic principles of mathematics for the treatment of observed physical phenomena. This analytical aspect is of the utmost importance. It is an integral part of the basic approach to all areas of physical science. This approach, or method of science, has been summarized as "selective analysis, accurate measurement, and mathematical treatment."*

But it is not only the college teachers who complain. High school teachers of mathematics, physics, and chemistry also deplore the apparent lack of ability which faces them year after year. Because of this situation standards have fallen, and chemistry and physics in high school have been called "souped-up general science courses." By and large, the main result of this lowering of standards has been

* Weber, White, Manning; *College Physics*, McGraw-Hill, 1952; page 2

the abandonment of mathematical treatment, which is most essential for the conversion of physical observations into useful concepts.

Do not, however, construe this discussion as an attack on mathematics teaching. It is not intended to be. Mathematics teachers have similar complaints to those of science teachers. Fundamentally, it appears that students are unable to think. By this I mean that there is a lack of ability to tie together the elements of a problem, work out a logical solution, and then solve the problem. To illustrate; well over 30% of the students I have taught physics and chemistry are not able to produce a solution to a problem which requires more than one calculation. This large group seems unable to visualize a process in which it is necessary to calculate a figure which will be used in subsequent calculations. But they are quite able to solve problems requiring only a single calculation. The trouble is not so much mathematics, but rather a difficulty in projecting a solution in their minds. They are not able to think in terms of a sequence of events within a problem situation.

Think of a conventional science learning situation. The instructor tells the story as well as he can, and after discussion receives from his students acknowledgement that they understand. He will present a demonstration, and the students perform an experiment illustrating the concept being studied. Problems are assigned. Some may involve mathematics, but all involve utilization of the concept. During the next session the problems are reviewed to clear up misunderstandings. At this point the student should have a fair grasp of the material.

The next step is to differentiate between mere memorization and actual learning. A quiz is given, in which the student is introduced to novel situations, and is asked to use the ideas he has learned to produce solutions. It is here that the troubles start. The student has not rehearsed the problems, and therefore must ***think*** his way through them. Needless to say, many do not, and in reality have failed to accomplish anything worthwhile. But they are able to spout poorly understood facts, and demonstrate the solutions to simple problems they have memorized. And, of course, they soon forget most of the memorized material.

Here is the basic trouble. Our elementary and secondary schools are not teaching students to think. They concentrate on the memorization of facts and procedures, and ignore the vitally important area of original thought.

We see then a dual challenge for science teachers. They must attempt to interest youngsters in scientific careers, but they must also inaugurate a program of teaching how to think. And this is the difficult task, for the introduction of reasoning experiences can frighten

the poorly prepared student away from scientific study, unless he is brought along slowly and carefully. Let's face it, we must nurse him along until he is able to stand on his own feet.

I doubt seriously if there is a ready answer for the questions raised above. But surely, the nation's science teachers must do everything within their power to stimulate interest and better prepare students for further training.

In my own course I place a heavy emphasis on problem solving. This includes both mathematical treatment and the analysis of physical phenomena in order to reach logical conclusions. Students often remark that it takes them an hour to solve a problem, but they approve when I point out that the solution involved understanding and utilizing several basic concepts. They heartily endorse my claim that this is a more valuable study experience than memorizing definitions.

In addition, I include as many quantitative experiments as possible. These are particularly instrumental in developing the ability to use the scientific method. Frequently, the students are asked to evaluate their experimental work with an eye to the scientific method. This helps them to visualize the essential steps involved in solving any problem, scientific or otherwise.

It is my belief that the scientific method, and the reasoning process which it represents, are merely given lip service in the majority of secondary schools. I feel that it is the job of the teacher to rise above this sedentary state of affairs, and to carry his students along with him. In my experience, this latter type of learning has carry over value to life as well as to advanced training in science.

HEART ATTACK DEATHS INCREASE AMONG WOMEN

Since 1940, a startling change has occurred in the number of men versus women who die from heart attacks, Dr. Wilbur A. Thomas, department of pathology, Washington University, St. Louis, Mo., reports in the April issue of the journal *Nutrition Reviews*. Before 1940 there were two men for every woman victim, but since then women victims have so increased that the ratio is now about one to one, he reported.

This and other unexpected facts were revealed by a study of 17,000 autopsies performed between 1910 and 1954 on victims of heart disease. The study was made to determine the prevalence of acute myocardial infarction, one of the most common causes of death in the United States. The condition is caused by an inadequate supply of blood to the heart muscle and results in "heart attacks" that usually bring severe pain and disablement. Twenty-five per cent to 35% of the victims of these attacks die from them.

Another unexpected finding concerns the difference between white and Negro populations, with five times as many white victims as Negro ones. A difference between the two races was known to exist before, but this latest study showed that the difference is increasing rather than decreasing, Dr. Thomas reported.

He cautioned against attributing it to genetic factors until every other possibility, especially dietary habits, has been exhausted.

WHAT PROPORTION OF CLASS TIME SHOULD BE USED IN TESTING?

R. F. GRAESSER
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The following discussion is an attempt to apply some of the theory of sampling to the question, what proportion of class time should be used in testing? The discussion does not presume to settle this question for it only considers one, perhaps minor, aspect of the question. Furthermore, assumptions have been made which the reader may be unwilling to accept. With these limitations, the discussion attempts to draw some conclusions that might be considered either interesting or amusing.

Suppose an instructor, at the end of a semester, assigns to each student in his class a per cent grade. He may use these per cents to rank his students and then to assign to them conventional A, B, C, D, E grades. But these per cents usually represent the proportion p' of the questions that the student has been able to answer correctly out of the total number of questions that the instructor has set on tests during the semester. What the instructor would like to know is p, the proportion of questions the student could answer out of all of the possible questions that could be reasonably asked concerning the course. Since the instructor can not determine p, he must approximate it by p' determined by asking n sample questions on tests during the semester. We wish to obtain first some idea of an approximate size for n. Since we would expect n to be rather large, the variable p' would have an approximately normal distribution with a standard deviation of $\sigma = \sqrt{pq/n}$, where $q = 1 - p$. Then approximately 95% of all of the sample values of p' would be within a range of 2σ on either side of p. If, 95% of the time, we wanted our estimate of a student's p to be in error less than 1/25, or 4%, we should have $2\sqrt{pq/n} < 1/25$. Hence $n > 2500\ pq$. As a problem in sophomore calculus, it can be readily shown that the maximum value of pq is $\frac{1}{4}$. Hence we can be reasonably sure of our desired accuracy if $n > 625$.

Next we wish to estimate the proportion of class time which should be used in testing. For this purpose, we might consider the briefest type of question, which is, perhaps, the true-false or the multiple-choice type. Assuming these may be answered at the rate of one per minute, we should spend 625 minutes in testing during the semester. In a three semester-hour course meeting three fifty-minute periods per week for eighteen weeks, this would be 23.1% of the total class time. If we had wished to keep our error in p' less only than 1/20, this per cent would have been only 14.8.

OUR SCIENCE MANPOWER SHORTAGE

GLEN W. WARNER
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In an article published on page 447 of this issue is given one viewpoint on the shortage of students majoring in science. This is an excellent article and should be read by everyone. But does it give a completely comprehensive view of the entire stiuation? Is the picture complete?

Throughout our land a great majority of our high schools are small institutions. Many of them have less than 300 students, often less than 100, enrolled. In many of them it is impossible, on the funds made available, to equip and maintain laboratories for chemistry and physics. In most of them a teacher is not available who is fully prepared to teach these subjects, because she must teach two or three other classes along with the science courses. In many of these schools no plans have been laid for suitable laboratories when the buildings were constructed. Hence pupils are graduated from these schools without courses worthy of the name physics or chemistry, or even without knowing anything about such a course, then sent off to college to compete with students from the large high schools where they have been taught by well trained teachers and in laboratories fully equipped and maintained. Can we expect these girls and boys to enroll in such classes, knowing that they will be eliminated from them within a few weeks, and possibly also from college? They have a fairly good idea of the situation because they have friends and acquaintances from preceding graduating classes who have traveled this road.

These young people have all had four years of high school work. Does it not seem that they may excel in some other work that pupils from the large high schools may have omitted in order to take the laboratory classes? Have our colleges ever considered giving such students a college credit class in the elementary science and relieving them from some other courses they may have taken? These students (or their parents) are paying taxes to keep the state universities going, hence have some right to expect to enter the university and to remain there to complete the college course. This is not an argument that they shall be allowed to enter a science class without the proper training, but they should be given that training without loss of credit time. Our universities should provide such classes, taught by expert teachers employed as regular professors on salaries as professors, not just by graduate students interested only in their research problems. It is true that the colleges now have more problems to solve than they have either time or money for doing the work. Possibly an intensive summer course would prove sufficient. The legislative branch

of the state government would probably listen to an appeal for funds for the operation.

Would not this be a much better way to increase the number of scientists than to depend on the wonderful efforts now being made by some of our large engineering firms in providing scholarships? They are filling a small gap but cannot be expected to attract students who have never had a chance to get the essential fundamentals.

Let our small high schools be given a chance to get science. They have shown that they can come to the top in athletics. If the same encouragement were given in science instruction, and a little cooperation from our great institutions, might some of them not also show that they can go ahead in science as well as in basketball? This may require a little additional money for laboratories and teachers, or a little less spent for elaborate gymnasiums and more for science instruction. Our universities will need only to add a professor or two to their faculties and the rooms for the classes and laboratory work.

SCIENTIFIC SLEUTHING LEADS TO "LOST JADE MINES" OF MEXICO

What has been called "one of the best-kept secrets of our time," may have been tracked down through a clever piece of detective work by Dr. Thomas Clements, curator of mineralogy at the Los Angeles County Museum and head of the geology department at the University of Southern California. The secret is the location of the rich veins of jade which have provided gem stones for Mexican artists since Aztec times. Dr. Clements is convinced that he has located at least one of the "lost mines" and hopes to uncover the actual site when he returns to the area next July.

The first steps toward hunting down the "lost mines" were taken by the late Dr. Raymond J. Barber, who preceded Dr. Clements as curator of mineralogy at the County Museum. Dr. Barber made an intensive study of ancient Mexican archives, some of which listed the tribute paid to Montezuma by the various provinces of his empire. By plotting on a modern map those cities that made yearly contributions in jade, or "chalchihuitl" as it was then called, Dr. Barber identified a narrow belt of some 68 towns. He then compared this belt with contemporary geological surveys of Mexico to find the location of metamorphic rocks where jadeite is most likely to be found.

Following Dr. Barber's death in 1955, Dr. Clements continued his researches. Recently he went on an expedition to Mexico during which he and his wife traveled 10,000 miles in a jeep. They interviewed local Indians, examined specimens, and tracked down countless clues. They finally found specific evidence of a deposit outside Taxco in the state of Guerrero. Dr. Clements is convinced that the deposits really exist and that some of them are still being worked by modern Indians, who continue to bring in raw stones to the cities for sale to local craftsmen and traders. "It is more than possible that the jade mines of Mexico were never really lost at all," he concludes, "but are simply one of the best-kept secrets of our time."

Nature is ever making signs to us, she is ever whispering to us the beginnings of her secrets; the scientific man must be ever on the watch, ready at once to lay hold of nature's hint, however small; to listen to her whisper, however low.

—M. Foster

CAPACITOR DISCHARGE AND ENERGY

AN INTERESTING DEMONSTRATION EXPERIMENT

J. O. PERRINE

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The demonstration is to illustrate and make interesting and convincing some of the basic facts about a capacitor, sometimes misnamed a condenser, particularly the fact that it is essentially an energy storing system in the form of electrostatic field embodied in the dielectric between the metal plates.

Of course in an oscillatory circuit, a capacitor interchanges its energy with an inductance. It is very important to talk about the interchange of energy from the very first discussion of capacitors and inductances.

The apparatus items are a 10 microfarad capacitor, a 1 microfarad capacitor, a 20 megohm resistor, a switch and a two plate neon lamp.

MODUS OPERANDI

From a suitable direct voltage source, 200, 400, or 600 volts is applied to a 10 microfarad condenser with the switch open (see Figure 1).

Energy in the form of electrostatic field is stored in the dielectric of the capacitor. It should be stressed that the energy is in the dielectric between the metal sheets and not in the metal.

When the switch is closed, a so-called leakage current of small magnitude leaks through as it were, the 20 megohm resistor and charges the 1 microfarad capacitor. Since the neon lamp flashes at about 110 volts, the voltage of the small capacitor is built up to that value in this particular case. After a little while voltage is built up on the 1 microfarad capacitor and a small bit of energy is transferred from the large capacitor to the small capacitor. When the voltage on the small capacitor is sufficiently built up, say to 110 volts, it flashes the neon lamp connected in parallel with small capacitor. The energy stored in the electric field of the small capacitor is spent to flash the neon lamp. After the flash, another bit of energy is transferred from the large capacitor to the small capacitor and a second flash of the neon lamp occurs.

The above process happens again and again, upwards of 100 or more times.

Of course the frequency of the flashes slowly decreases as the energy and voltage on the big capacitor decrease. The frequency of the discharge depends of course all the time on the magnitude of the resistor and the capacitance of the two capacitors.

The frequency also depends on the break down voltage or flash voltage of the neon lamp.

To illustrate frequency as dependent upon the above mentioned, it would be nice to have a different set up with different values of capacitances and resistors.

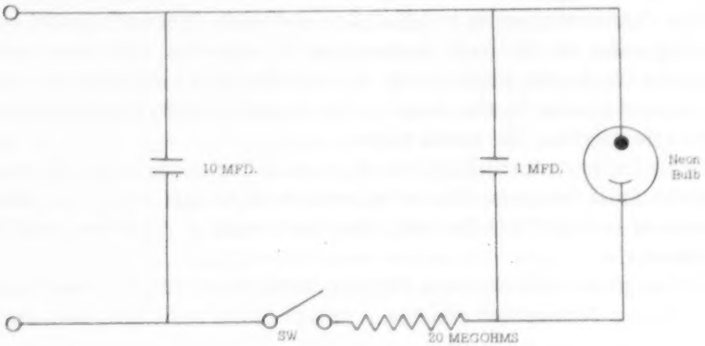

FIG. 1. Demonstration equipment to show storage of energy in a capacitor.

The idea would be that previous to demonstrations before a class some energy could be put into the big capacitor by applying 600 volts.

Then the ensemble as shown in Fig. 1 can be set on the table before the class or visitors. There are no batteries present, there are no connections, there is only a tank full of energy, like a cylinder full of compressed air as it were.

The neon lamp flashes and flashes periodically and one's interest and inquisitiveness are aroused.

AMOUNT OF ENERGY

The amount of magnetic field energy stored in the magnetic field around a permanent magnet is very, very small. I have made some fairly good calculations of the energy stored in the magnetic field of the permanent magnet in a magnetron of a radar transmitter. The magnitude is surprising; about a hundred millionth of a watt hour. Furthermore, it is not easy to know the factors of flux and magnetomotive force so as to calculate this magnetic field energy. One must have a magnetization curve and hysteresis loop with values of flux, etc., well known.

However, the energy stored in a sizable capacitor is also comparatively small and is easily found. It is not difficult to know voltage applied and it is not difficult to determine the capacitance of the capacitor. Furthermore the relations of energy, voltage and capacitance are straight-forward.

$$\text{Energy} = E = \frac{CV^2}{2} \qquad V = \text{Voltage}$$

$$\frac{QV}{2}$$

In the second form of the simple equations Q is coulombs of charge i.e., an ampere second.

Therefore Farads = Coulombs per volt by definition of capacitance

$$\text{Coulombs} = \text{farads} \times \text{volts}$$

$$W = \text{Energy} = \frac{\text{ampere seconds}}{2} \times \text{volts} = \frac{\text{coulomb volts}}{2} = \text{farad volts}^2$$

$$= \frac{\text{watt seconds}}{2}$$

So the equation

$$W = \frac{CV^2}{2}$$

gives energy in watt seconds when C is farads and V is volts.

$$10 \text{ microfarads} = .000010 \text{ farads}$$

Assume the voltage applied is 600 volts

$$W = \text{Energy} = \frac{.000010 \text{ Farads} \times 360{,}000 \text{ (Volts)}^2}{2} = 1.8 \text{ watt seconds*}$$

$$= \frac{1.8}{3600}$$

$$= .0005 \text{ watt hours}$$

$$= 1.3 \text{ foot pounds}$$

With this seemingly small amount of energy of .0005 watt hours, stored originally in the big capacitor, the neon lamp can be made to flash upwards of a hundred or more times. The amount of energy of each bit of light is therefore very small.

It must be remembered, too, that a tiny bit of energy is wasted in the resistor all the time switch is closed.

A lot of good ideas are discussable in terms of this training aid. The smallness of energy involved in capacitors is a most important idea. Capacitors are ever present in all the forms of electrical communication equipment.

* 1 watt second = .73 foot pounds.

Electrical Terms

The terms used in electrical and radio engineering have a distinctly technical meaning. The words, current, resistance, and electromotive force, are in themselves indicative of the kind, the nature, or quality of the factor for which they stand.

The layman used the words resistance, current, and force to apply to aspects of his everyday physical environment other than electrical. Therefore, when he by chance gives attention to electrical phenomena, the words resistance, current, and force are accepted at their face value.

Voltage

The term voltage is quite commonplace among laymen. When this layman is told that voltage is comparable to "head" of water in a supply tank or dam he accepts the analogy quite readily. When he is presented with the idea that "head" of water measured in feet of height gives rise to a pressure at the bottom of the standpipe or dam, he again subscribes. When he is informed that "head" measured in feet is quite a different sort of thing than the pressure at the bottom measured in pounds per square inch, he again subscribes to idea quite readily.

So when his electrically trained informant says, "Well, voltage in our business is like 'head' of water; it is the electrical 'head'; instead of feet of 'head' we use the term volt; one volt of electrical 'head' will drive a current of one ampere through a resistance of 1 ohm; thereupon the layman still subscribes quite readily."

At this juncture, we say to the layman, "Well, we electrical fellows are a bit inconsistent, we measure the 'head' of our electrical system in volts and also we measure the pressure, the pounds per square inch as it were, with the same term, volt! We do not have a separate term to measure this electromotive force, a sort of electrical pressure."

So actually, in electrical matters, we measure "head" or voltage in volts and we measure electromotive force in volts. "Head" of water in feet gives rise to a pressure in pounds per square inch. "Head" or voltage of an electrical energy source in volts gives rise to an electrical pressure and electromotive force in volts. The whole deal is a bit inconsistent and unscientific. Actually, of course, we do not use the term electromotive force except as a concept, the analogue of pressure; we do not use it as a force in electrical equations for calculations.

When we multiply voltage times current to get power (volts times amperes), we are using voltage in its more strictly correct meaning as a "head." Otherwise, we could not get power in watts by multiplying volts times amperes. Electromotive force times amperes could not give power in watts.

Inductance

Our lay friend is not receptive to the word "inductance." It has no analogue in his ordinary physical environment except perhaps to inertia of a body. So we will not discuss the meaning of inductance any further in this short essay. The word itself means nothing to him as does resistance.

Condenser, Capacity, Capacitance

The words condenser and capacity as descriptive of quantities possessed by electrical apparatus are actually misnomers. The words themselves give the wrong impression of the electrical quanitites involved. An electrical condenser does not condense anything; it is not like a "condenser" in a steam plant where steam is condensed to water.

To think of a condenser as a device to condense electricity is away off the beam; no such concept could be farther from the real fact and truth.

The word capacity itself of a condenser implies an incorrect idea. The capacity of a condenser in farads or microfarads is not the charge or amount of electricity, measured in coulombs, that the condenser can store, but is the charge per volt. Capacitance is the coulombs per volt, i.e. farads.

A coulomb is the amount of charge or quantity of electricity resulting when a circuit of one ampere flows for one second.

$$\begin{aligned} Q &= \text{charge} = \text{coulombs} = IT \\ &= \text{current (amperes)} \times \text{time (seconds)} \end{aligned}$$

In passing, it is to be observed that an electron is a charge of 4.774 electrostatic units. The finding or determination of the charge of an electron was first made about 1909 by Millikan at Chicago University and made him famous. Instead of the 4.774 electrostatic unit value, one could also say that an electron is 1.592×10^{-19} coulombs. This means that a coulomb of charge, of quantity of electricity is $6.28 \times 10^{+18}$ electrons.

Speaking generally of water tanks rather than electrical tanks (as a capacitor might be regarded), the capacity of a water tank does mean the number of pounds of water it can hold. But the capacity of a capacitor, and the better and strictly correct word to be used is capacitance, is the charge a capacitor (no longer ought we say condenser) can hold or store per volt of potential or "head."

The proper word to use is capacitance, not capacity.

The proper word to use is capacitor not condenser.

In terms of a simple formula

$$\text{Farads} = \text{Capacitance} = C = \frac{\text{Charge in Coulombs} = Q}{\text{Potential in volts} = E}.$$

A Tank Analogy

Assume we have two water tanks as illustrated in Figure 2.

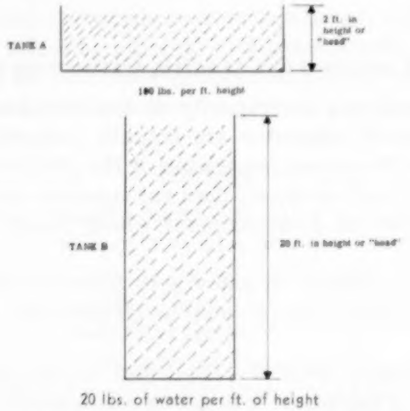

FIG. 2. Water tank analogue, of electrical capacitor.

As seen from dimensions of tank A it would hold 200 lbs. of water or $Q=200$ pounds. Tank B would hold 400 lbs. of water or $Q=400$ pounds. As far as water tanks go, tank B does have greater capacity in the usual sense of the term.

However, per foot of height or head, tank A holds 100 pounds of water, $Q=200$ lbs. Tank B, however, holds 20 lbs. of water per foot of height or head. $Q=$ quantity of water $=400$ lbs. which is more than tank A.

In electrical language, Tank A has greater capacitance, namely 100 pounds of water per foot of head. Of course if tank A were also 20 feet high, it would hold more pounds of water than Tank B, but this is beside the point at issue. The point is that tank A has greater capacitance; more pounds of water per foot of head than tank B.

Electrical capacitance of a capacitor in farads or microfarads is then the charge measured in electrons or coulombs per volt of "head" or potential; not how much charge can be stored or put into it.

How much water or how much charge can be put into a water capacitor or an electrical capacitor depends on two factors, the capacitance as herein properly defined and the head of water in one case and volts in the other case.

Capacitance, Capacitors

To avoid the incorrect connotations of the words condenser and

capacity it might be well to try and drop these words and always use the correct terms, capacitor and capacitance.

Energy Stored in a Capacitor

As discussed in several collateral memoranda, the capacitor's basic purpose in electrical matters is to store energy either semi-permanently or for short periods of time. It is a kind of stored or potential energy.

The energy in watt seconds is obtained by the formula.

Fig. 3. Capacitor discharge assembly.

$$\text{Watt seconds} = W = \text{Work} = \frac{CV^2}{2} \quad \text{where } C \text{ is in farads and } V \text{ is in volts.}$$

From the very beginning when the capacitor has no charge put in it and also when the voltage on it is 0, to the time at end of charging process with a charge of Q and the voltage is E, it can be correctly assumed that the average voltage achieved by the capacitor is $\frac{1}{2}E$. Also it can be correctly assumed that the work or energy involved in getting the charge into it is the same as if the total and final charge Q had been carried or lifted from a condition or zero E to a condition of $\frac{1}{2}E$. Therefore Work = Energy = $\frac{1}{2}EQ$. Now C = by definitions = Q/E

This means that $Q = EC$.

Therefore finally W = Work done = Energy Stored

$$= \frac{E}{2} \cdot EC = \frac{CE^2}{2} \cdot$$

ENERGY STORED IN A WATER TANK

Water stored in a tank represents a certain amount of stored energy. The amount of energy stored is potential energy and depends on the capacitance of the tank, namely its pounds of water per foot of head and the amount of height or "head."

Tank B has a capacitance of 20 lbs. per ft. and is 20 feet high. Its Q or quantity of water is 20 lbs. per ft. times 20 feet or 400 lbs. of water. The Q of water, that is the 400 lbs. of water, is like the Q of charge of an electric capacitor in coulombs.

Now as in arriving at work done in putting a charge in an electrical capacitor and getting the energy of electrostatic field stored in the dielectric of the capacitor and getting $W = \text{Work} = \text{Energy} = \frac{1}{2}CE^2$ so we can get a similar looking and meaning formula for the potential energy stored by having water in a tank.

The average height of the water up which the water was lifted was $\frac{1}{2}H$ where H is head in feet rather than electrical head in volts.

The capacitance of the tank is lbs. per ft.

$$C = \text{lbs. per ft.} = \frac{\text{lbs.}}{\text{feet}}$$

$$\text{Total Pounds} = CH = Q$$

Therefore Q pounds or CH lbs. have been raised to an average head $\frac{1}{2}H$.

Therefore work done to put the water into the tank and the energy stored in the water is

$$CH \text{ lbs. times} \frac{H}{2} = \text{force times distance}$$

$$\text{Work} = \text{Potential Energy} = CH \times \frac{H}{2} = \frac{CH^2}{2}$$

$$= \text{foot pounds}$$

Finally then we have an expression or formula for potential energy of water stored in a tank which is of the same mold as the formula for energy stored in an electrical capacitor.

This formula for water tank energy probably would not be found in textbooks of hydraulics. The reason is that the hydraulic engineer does not use the term capacitance of a water tank in lbs. per ft. of height as does the electrical engineer for capacitors in coulombs per volt or farads.

Conclusion

The whole point of this essay is to present the proper point of view and understanding of the meaning of the electrical terms capacitor and capacitance.

Dielectric Strength

Furthermore one concluding point might be appropriately discussed.

How high a voltage can be applied to a capacitor to store a lot of energy in it before it "sparks over" depends on the dielectric strength of the insulator between the metallic surfaces of the capacitor. The dielectric strength of the insulator in volts per unit thickness before breakdown or puncture depends on the kind or nature of the dielectric.

Dielectric strength is sometimes called sparking potential. For glass, it varies from 300 to 1500 kilovolts per centimeter, for mica it varies from 1500–2200 kilovolts per centimeter, for beeswaxed paper it is 770, for paraffin it is 75, for rubber it varies from 160 to 500, for ebonite it varies from 300 to 1100, for paraffined paper it is 500 and for varnished paper it varies from 100–250 kilovolts per centimeter. (1 inch = 2.5 cm.)

For water tanks, the dielectric strength if we analogize, would depend on the material of the tank, be it steel, tile or paper. When the tank would burst or "spark over" as it were, would depend on sheer mechanical strength of tank.

Dielectric Constant

In the electrical capacitor, the capacitance depends on the nature or kind of the insulator between metal plates. The nature or kind of dielectric is measured by the term specific inductive capacitance or dielectric constant. This term is defined as the ratio of the capacitance of a capacitor with the particular material and dielectric to the capacitance of the same size and shape capacitor with air or vacuum as a dielectric.

The dielectric constant of extra heavy flint glass is 9.9, mica varies from 5.6 to 5.9, shellac is 3.8 and paper varies from 3 to 5.

Now dielectric strength and dielectric constant are specifically different factors and must be carefully differentiated.

The arrangement of apparatus shown in Figure 1 is very simple. The items of apparatus are readily obtained. The interest aroused in beginning and advanced classes in electricity is most gratifying.

The history of man is dominated by and reflects the amount of available energy.

SOME TECHNIQUES FOR IDENTIFYING CHILDREN'S SCIENCE INTERESTS

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Interest as a factor in the learning process has long been recognized despite a somewhat nebulous understanding of its origin, development, and implications. Science educators, especially, have been cognizant of this important factor in planning science experiences in the elementary school. The value of pupil interest as an educational springboard is accepted by most educators, but the identification and utilization of interests has often been difficult for the classroom teacher.

In a recent study[1] it was found that several techniques should be used to identify children's science interests. Two instruments were devised which may help teachers more easily determine children's interests in science topics. General interest inventories, essays, and observation are also helpful in studying interest patterns.

Many teachers give a general interest inventory as school opens in the fall. This may include such questions as: What do you like to read about? What would you like to learn more about this year? What have you liked best in science? and Are you making any collections? The answers to these questions give some information about the child's interest in science.

"Projective techniques" may also be used to identify children's interests in science. Two instruments have been devised which would reveal the interests of the child in nine categories of science: animals, aviation, energy, growth and development of the human body, machines, plants, weather, and the universe.

One instrument was called *Wondering Questions*. Eight questions related to each category provided opportunity for the child to indicate degree of interest as he checked one of the possible responses. These responses were "I have never wondered about this and I am not interested," "I now wonder about this and I would like to know more," and "I know some things about it and would like to know more."

The questions were derived from the study by Baker[2] and from a similar study conducted by the writer in which children were asked what they would like to know about. Both specific and general questions were included. For example, the item "Birds" was selected in

[1] Doris Young, "Factors Associated With the Expressed Science Interests of a Selected Group of Intermediate Grade Children" (unpublished Doctor's dissertation, Northwestern University, Evanston, Illinois, 1956).

[2] Emily V. Baker, *Children's Questions and Their Implications for Planning the Curriculum* (New York: Bureau of Publications, Teachers College, Columbia University, 1945).

addition to the question, "Why birds fly south in winter." Some examples of questions included are: "How jets fly," "Life on the planets," "Animals that lived long ago," "Flying saucers," "How electricity is made," and "How we breathe."

A second instrument found useful in identifying children's interests was a ***Film Choices*** questionnaire. Eight film titles were selected to represent each of the categories. A brief description of the film was included with the title. When the questionnaire was first given the children, they were asked to indicate degree of interest by checking one of these columns: "I would not be interested in seeing the film," "I have some interest in seeing this film," "I would be very interested in seeing this film."

The film titles had been paired in order that forced choices would be made when the instrument was presented on the second day. At this time the children were asked to check the film title they would prefer if they had to choose between each pair. Titles were arranged so that choices between all categories were forced. For example, the child would have to select ***Exploring Space*** or ***How Jets Work***, ***The Solar System*** or ***Winds***, ***Our Universe*** or ***Telephone and Telegraph***, ***The Milky Way*** or ***Flames at Work***, ***This Is the Moon*** or ***City of Wax***, ***The Moon*** or ***Making Electricity***, and ***The Sun's Family*** or ***Heart and Circulation***.

By scoring the responses it was possible to determine the degree of interest in science and the peaks of interest in each category. These instruments made it possible to determine areas in which there was very little science interest. Ascertaining negative responses is important in planning science activities. With this information the teacher may provide experiences which will extend and broaden children's interests.

Essays written by children in the intermediate grades may further reveal science interests. In the study cited it was found that the children made many comments about science as they wrote about the topics, "What I Like About School" and "What I Dislike About School." These references, related to content as well as method, gave the teachers some valuable clues for improving the science classes.

Children reveal their interests if they are encouraged to bring objects, collections, news items, and interesting stories to a sharing period. The teacher's record of these contributions will aid in understanding the child's interests and in planning ways to develop further interests.

Elementary science teachers are challenged by the need to utilize children's interests in science. One general interest inventory given in the fall is inadequate in solving this problem. Continued study of

children's interests, with the use of several instruments and records of observations, is essential if satisfying and educative experiences are to be provided in the science curriculum.

PHILATELIC DISPLAYS FOR THE MATHEMATICS AND SCIENCE CLASSROOM

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Framed exhibits of stamps illustrating scientific topics make attractive and interesting displays. A teacher without previous knowledge or experience in stamp collecting can easily prepare one or more such frames for exhibit in the classroom or elsewhere. Not only will students find the teacher-constructed displays interesting but they may be led to the construction of similar displays themselves. This can serve the twofold purpose of furthering interest and knowledge of things scientific and promoting an interesting hobby, philately.

A convenient size for such a display is afforded by an 18″×24″ picture frame. The stamps and accompanying lettering will show most effectively against a white background. Stamps should be mounted with stamp hinges which are available at most book stores at about twenty cents per thousand. Captions and explanatory text should be kept brief to allow the stamps to hold the center of attraction. From twenty to twenty-four stamps per frame is about maximum for best effect. In some cases a smaller number may be desirable.

The teacher-collector will undoubtedly find many stamps usable for such a display among his duplicates. The non-collector will find most of the stamps easily obtainable from a local stamp dealer. If there is no stamp dealer in your city the address of one can be obtained from a local collector or from magazines. Stamps may be ordered on approval. Prices will mostly be below Scott catalogue[1] prices.

Listed below are some stamps useful for such displays. These have been grouped into five fields, but these are only some of the possibilities. A frame combining two or more of these fields might be made. For examples: Physics and Chemistry, Astronomy and Mathematics, or Science on Stamps. In several cases there are enough different stamps available to make exhibits of more restricted topics, e.g.: Animals on Stamps, Mining and Metals, or Medicine. The lists given are not intended to be exhaustive.

Stamps are listed by topic illustrated, followed by the name of the country issuing the stamp, the date of issue, and the Scott catalogue number.

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[1] *Standard Postage Stamp Catalogue*, Scott Publications, Inc., New York. Published yearly.

ASTRONOMY:

Brahe, Tycho
Denmark 1946 300
Constellation: Big Dipper
Japan 1952 552
Constellation: Sothern Cross
Brazil 1939 B10
Constellation: Southern Cross
Japan 1952 553
Copernicus, Nicolaus
Poland 1953 579
Diagrams, Russell
. Mexico 1942 C125
Eclipse, Solar
Mexico 1942 775
Galaxy, Spiral
Mexico 1942 776
Galaxy, Spiral
Mexico 1942 C123
Galileo Galilei
Italy 1942 421
Galileo presenting telescope to Doge
Italy 1942 420
Galileo studying at Arcetri
Italy 1942 422
Galileo teaching mathematics
Italy 1942 419
Nebula, Dark
Mexico 1942 774
Nebula, Planetary
Mexico 1942 C124
Observatory
Japan 1953 591
Observatory, Kyongju
Korea 1946 69
Observatory, Palomar
U. S. A. 1948 966
Observatory, Pic du Midi
France 1951 673
Telescope, Floating Zenith
Japan 1949 478

BIOLOGY:

Audubon, John James
U. S. A. 1940 874
Avicenna
Afghanistan 1951 390
Bacteriological Building
Peru 1905 165
Balsam gathering
Salvador 1935 566
Balsam extracting
Salvador 1939 580
Botanic Station
Montserrat 1938 95
Burbank, Luther
U. S. A. 1940 876
Cactus, Turk's head
Turks and Caicos Islands 1910 23
Chicle tapping
British Honduras 1938 116
Coffee tree in bloom
Salvador 1940 C73
Condor
Bolivia 1939 265
Darwin, Charles
Ecuador 1936 343
"Doctor, The"
U. S. A. 1947 949
Koch, Robert
Belgium 1953 B554
Leeuwenhoeck
Netherlands 1937 B97
Medical School
Afghanistan 1950 367
Ophthalmological Congress
Egypt 1937 220
Pasteur, Louis
France 1923 185
Tsetse fly laboratory
Cameroons 1954 C33
Vesalius, Andreas
Belgium 1941 B320

Not listed above are stamps showing animals, birds, or flowers These are very numerous, both as single stamps from different countries, or as sets of stamps. Many of these are in natural colors and are generally inexpensive except for the end values of the sets in some cases. Frames exhibiting animals, birds, or flowers could be of interest to students in Junior High School or the lower grades as well. Here is a particularly good opportunity for the students to make their own topical collections. As only a few examples of the sets available, the following are worthy of note:

Animals;
  Angola 362–381
  Hungary c96–c102
  Italian Somaliland C40–C45 (Antelopes)
  Liberia 283–288
Beetles;
  Hungary C136–C145
Birds; Angola 333–356
Butterflies and Moths;
  Mozambique 364–383
Fish;
  Mozambique 332–355
Flowers;
  Belgian Congo 263–282
  Belgian East Africa 114–132

Most stamp issuing countries have a few stamps showing Nursing on stamps and a fairly extensive display could be made of these.

CHEMISTRY:
  Alcohol (Rectifying tower)
    Japan 1948 416
  Bequerel, Henri
    France 1946 B202
  Blast Furnace
    Russia 1941 818
  Cement Factory
    Persia 1935 791
  Chemical Industry
    Canada 1956 363
  Chemical Society, American
    U. S. A. 1951 1002
  Chemist
    Czechoslovakia 1954 657
  Chemist
    Belgium 1951 B492
  Chemist, Agricultural
    Germany 1934 B65
  Chemistry Student
    Romania 1952 905
  Claire-Deville (Aluminum)
    France 1955 760
  Copper Mine
    Chile 1938 201
  Copper Pyrites Mine
    Dominica 1955 171
  Curie, Pierre and Marie
    France 1938 B76
  Daguerre and Niepce
    France 1939 383
  Gay-Lussac
    France 1951 B260
  Lavoisier, Antoine
    France 1943 464
  Metallurgical Plant
    Russia 1947 1172
  Nickel Foundry
    New Caledonia 1948 285
  Nitrate Industry
    Chile 1938 201
  Oil Refinery
    Persia 1953 970
  Pharmaceutical Industry
    Costa Rica 1954 C246
  Phosphate loading
    Nauru 1954 41
  Phosphate Loading Jetty
    Gilbert and Ellice Islands 1939 48
  Platinum Mine
    Colombia 1932 414
  Rubber Industry
    Costa Rica 1954 C242
  Sugar Industry
    Jamaica 1938 125
  Tin Dredging
    Nigeria 1936 40

MATHEMATICS:
  Descartes, René
    France 1937 330 and 331 (330 is inscribed "Discours sur la Methode" corrected in 331 to "Discours de la Méthode")
  Gazeta Matematica
    Romania 1945 596
  Lobachevski, N. I.
    Russia 1950 1575
  Monge, Gaspard
    France 1953 B279
  Pascal, Blaise
    France 1944 B181
  Pythagorean School
    Greece 1955 582–585 (set of four)

The above were chosen as illustrating topics from mathematics likely to be familiar or of interest to High School Students. These make a good display combined with stamps illustrating topics from other sciences. The author titled one such display "Mathematics and Related Topics on Stamps" using the above stamps and others from

astronomy and physics. Some well known mathematicians whose fame derives from mathematics beyond the scope of the High School could also be included. Significant among these would be:

Euler, Leonard
Germany 1950 10N58
Gauss, C. F.
Germany 1955 729
Poincaré, Henri
France 1952 B279
La Place, Pierre S.
France 1955 B298
Leibniz, Gottfried Wm.
East Germany 1950 10N66

A fairly complete listing of mathematics on stamps is available elsewhere.[2]

PHYSICS:
Ampère, André Marie
France 1936 306
Atomic Electric Station
Russia 1955 1794
Atomic Symbol and Globe
Germany 1955 731
Atoms for Peace
U. S. A. 1955 1070
da Vinci, Leonardo
Italy 1952 601
da Vinci's Flying Machine
Italy 1932 C28
Edison
U. S. A. 1947 945
Edison's first lamp
U. S. A. 1929 654
Electronic Progress symbols
Egypt 1953 365
Einstein, Albert
Israel 1956 117
Gramme, Zénobe
Belgium 1930 217
Mercator, Gerardus
Belgium 1941 B324
Meteorological Observatory
Japan 1949 459
Metric System
France 1954 732
Microphones 1925 and 1950
Japan 1950 499
Orsted, Han Christian
Denmark 1951 328
Otto, N. A.
Germany 1952 688
Physics Class (Static Machine)
Romania 1953 935
Piccard's Balloon
Belgium 1932 251
Planck, Max
Germany 1952 9N92
Roentgen, W. K.
Germany 1951 686
Television Receiver
Italy 1954 649
Volta, Alexander
Italy 1949 527
Voltaic Pile
Italy 1949 526

If extended to include inventions and inventors many more stamps could be found for a physics or general science display.

[2] Larsen, H. D., "Mathematics on Stamps," *The Mathematics Teacher*, November 1955, pp. 477–480 and May 1956, pp. 395–396.

From time to time we seem to reach the stage in which the horizon of discovery is also its boundary.

—W. F. G. Swann

I could trust a face and always cross-question an assertion.

—Faraday

THE THEOREM OF THE MEANS AND ITS APPLICATION TO PROBLEMS OF MAXIMA AND MINIMA

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An important relation useful in solving many problems of maxima and minima without the calculus is provided by the inequality which exists between the geometric and arithmetic means of two or more numbers.[1]

Let $x+y=s$ (s constant) be a sum of two positive numbers. Then, as is evident by algebra:

$$(x+y)^2-4xy=(x-y)^2>0 \tag{1}$$

unless $x=y$ in which case the left-hand member equals to zero. Dividing both sides of inequality (1) by 4, transposing, and extracting roots, we obtain

$$\sqrt{xy}\leqq\frac{x+y}{2} \tag{2}$$

which states that the geometric mean of two positive numbers is no greater than their arithmetic mean. Equality results only if $x=y$. This is the theorem of the arithmetic and geometric means; or simply, the theorem of the means, for the case of two variables.

Inequality (2) has a geometrical interpretation. If x and y are the linear dimensions of a rectangle, then $(x+y)^2/4$ is the area of a square, and xy is the area of a rectangle with the same perimeter. Hence, inequality (2) states that of all rectangles with a given perimeter the square has the most area.

To obtain a similar result for three variables, we shall need to establish the inequality

$$\sqrt[3]{xyz}<\frac{x+y+z}{3} \qquad (x+y+z=s) \tag{3}$$

unless $x=y=z$ in which case the inequality becomes an equality.

Let $P_1=x_1y_1z_1$ be assumed to be as large as possible for a set of values $x=x_1$, $y=y_1$, $z=z_1$. If $x_1=y_1=z_1$, then our result is established. Otherwise, assume $x_1\neq y_1$, and set

$$x_2=\frac{x_1+y_1}{2} \qquad y_2=\frac{x_1+y_1}{2} \qquad z_2=z_1$$

[1] To my knowledge, the proof I give for $n=3$ is original. An excellent proof of the general case is given in G. H. Hardy's *Pure Mathematics*, p. 32.

It will be noticed that

$$x_2+y_2+z_2=x_1+y_1+z_1=s.$$

The new product is

$$P_2=x_2y_2z_2=\left(\frac{x_1+y_1}{2}\right)^2 z_1 \geqq (x_1y_1)z_1=P_1$$

in view of inequality (2) above. Hence, unless $x_1=y_1$, $P_2>P_1$, contrary to the assumption that P_1 was a maximum. Hence $x_1=y_1$. In the same way, we can prove that $x_1=z_1$, and hence $x_1=y_1=z_1$. Since

$$\sqrt[3]{xyz}=(x+y+z)/3$$

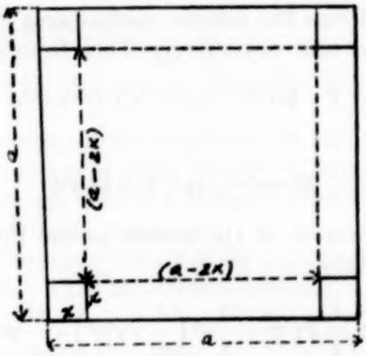
when $x=y=z$, and we have shown that only this set of values gives the maximum value of x, y, z, it follows that

$$\sqrt[3]{xyz}<(x+y+z)/3$$

otherwise. This proves inequality (3) above.

I now proceed to apply inequalities (2) and (3) to several typical problems of maxima and minima as found in calculus texts.

Problem 1. If is desired to make an open-top box of greatest possible volume from a square piece of metal whose side is a units by cutting off equal square corners and then folding up the resulting metal to form the sides. What should be the length of the sides thus cut off?



Let x = side of square cut out = depth of box.

Then $(a-2x)$ = side of square forming bottom of box.

The volume of the box is then $=(a-2x)^2x$. We begin with the identity:

$$(a-2x)+(a-2x)+4x=2a,$$

and choose for our variables $(a-2x)$, $(a-2x)$, $4x$. We now apply the theorem of the means, and arrive at

$$4V = 4x(a-2x)^2 \leqq \left[\frac{(a-2x)+(a-2x)+4x}{3}\right]^3 = \frac{8a^3}{27}\,.$$

Equality is attained when $4x = a - 2x$, or $x = a/6$.

Problem 2. Of all right circular cylinders having a given volume, show that the cylinder whose altitude is equal to its diameter has the minimum surface.

Let V, S, r, and h denote the volume, surface area, radius, and altitude of the cylinder respectively. Then from geometry

$$V = \pi r^2 h, \qquad S = 2\pi r^2 + 2\pi r h.$$

Here S is partitioned into two parts and the theorem of the means presumably fails to apply. But if we write S in the form

$$S = 2\pi r^2 + \pi r h + \pi r h$$

and apply the theorem to the variables $2\pi r^2$, $\pi r h$, $\pi r h$, we obtain

$$\left(\frac{S}{3}\right)^3 \geqq 2\pi r^2 \cdot \pi r h \cdot \pi r h = 2\pi^3 r^4 h^2 = 2\pi V^2$$

with equality true only for $2\pi r^2 = \pi r h$, or $h = 2r$.

Problem 3. Show that a cone of revolution of a given volume will require the least amount of surface when the height is $\sqrt{2}$ times the radius of the base.

Let V, S, r, h denote the volume, surface area, radius of the base, and altitude of the cone respectively. Then from geometry

$$V = \tfrac{1}{3}\pi r^2 h, \qquad S^2 = \pi^2 r^2 (r^2 + h^2).$$

We write

$$S^2 = \pi^2 r^4 + \tfrac{1}{2}\pi^2 r^2 h^2 + \tfrac{1}{2}\pi^2 r^2 h^2$$

and apply the theorem of the means to the three variables $\pi^2 r^4$, $\tfrac{1}{2}\pi^2 r^2 h^2$. $\tfrac{1}{2}\pi^2 r^2 h^2$. Hence

$$\frac{S^6}{27} \geqq \frac{1}{4}\pi^6 r^8 h^4 = \frac{81}{4}\pi^2\left(\frac{1}{81}\pi^4 r^8 h^4\right) = \frac{81}{4}\pi^2 V^4$$

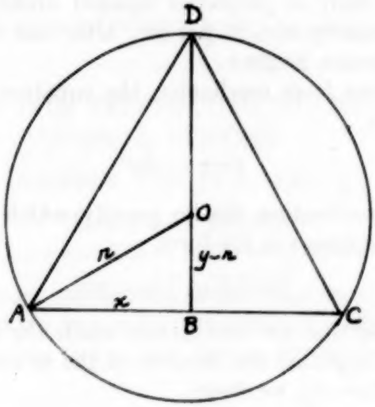
with equality true only if

$$\tfrac{1}{2}\pi^2 r^2 h^2 = \pi^2 r^4, \quad \text{or} \quad h = r\sqrt{2}.$$

Problem 4. Find the altitude of the largest right circular cone that may be inscribed in a sphere of radius r.

The figure to the right represents a section through the center of the sphere and the vertex of the cone. Let x be the radius of the cone

and y its height. Then $OB=y-r$. The volume $V=\frac{1}{3}\pi x^2 y$ is required to be a maximum.



From the right triangle AOB, $x^2=2ry-y^2$. Hence

$$V=\frac{\pi}{3}(2ry^2-y^3), \qquad (0\leqq y\leqq 2r).$$

We observe that

$$\tfrac{1}{2}y+\tfrac{1}{2}y-(2r-y)=\text{constant}.$$

Hence we factor V in the form

$$V=\frac{\pi}{3}\cdot 4\cdot \tfrac{1}{2}y\cdot \tfrac{1}{2}y\cdot (2r-y)\leqq\frac{4\pi}{3}\cdot\frac{1}{27}[\tfrac{1}{2}y+\tfrac{1}{2}y+(2r-y)]^3=\frac{32\pi}{81}r^3,$$

and apply the theorem of the means to the three variables $\frac{1}{2}y$, $\frac{1}{2}y$, $2r-y$. Equality occurs only when $\frac{1}{2}y=2r-y$, or $y=4r/3$.

Problem 5. Given the area of a triangle, show that the equilateral triangle has the minimum perimeter.

Let a, b, c, p, A represent the three sides, perimeter, and area of the triangle respectively. Then by Heron's formula,

$$\frac{A^2}{s}=(s-a)(s-b)(s-c), \qquad (s=\tfrac{1}{2}p).$$

Applying the theorem of the means to the three factors on the right, we have

$$A^2\leqq\frac{s^4}{3^3}=\frac{p^4}{2^4 3^3}$$

and there is equality only when $s-a=s-b=s-c$; that is when the triangle is equilateral.

Reversing the inequality, we also have the result: for a given perimeter, the equilateral triangle has the largest area.

Problem 6. A body is projected upward under the influence of gravity with a velocity of v_0 ft. per sec. After how many seconds will it attain its maximum height?

As is well known from mechanics, the equation of motion of the body is given by:

$$s=v\cdot t-\tfrac{1}{2}gt^2$$

where g is the acceleration due to gravity which is assumed to be constant. If we express s in the form

$$S=\tfrac{1}{2}g[(gt)\cdot(2v_0-gt)]$$

it will be observed that the two factors inside the bracket add up to a constant sum. Applying the theorem of the means to the two variables (gt) and $(2v_0-gt)$, we have

$$s\leqq\frac{1}{4}\cdot\frac{1}{2g}[(gt)+(2v_0-gt)]^2=\frac{v_0^2}{2g}$$

with a maximum attained only when $gt=2v_0-gt$, or $t=v_0/g$.

Problem 7. For what value of x does the quadratic function ax^2+bx+c attain its maximum or minimum value?

If $a>0$, let

$$y=ax^2+bx+c=-a(x-r)(s-x)(r\leqq x\leqq s)$$

where r and s are the zeros of the function. It is evident that the product on the right is negative or zero. Consider then the function

$$-y=a(x-r)(s-x)$$

where each factor is now positive or zero. By the theorem of the means

$$-y\leqq\frac{a}{4}[(x-r)+(s-x)]^2=\frac{a}{4}(s-r)^2$$

and a maximum is attained only when

$$x-r=s-x, \quad \text{or} \quad x=(r+s)/2=-b/2a,$$

where the last equality is due to the well-known relation between the roots and the coefficients of a quadratic equation. Hence y is a maximum for the same value of x.

If $a<0$, then

$$y=(-a)(x-r)(s-x)$$

has three non-negative factors, and as before

$$y \leq -\frac{a}{4}[(x-r)+(s-x)]^2 = -\frac{a}{4}(s-r)^2,$$

and a maximum is attained when $x = -b/2a$ again.

A VIBRATOR FOR PRODUCING STANDING WAVES IN A STRING

NUMBER TWO IN A SERIES

HARALD C. JENSEN
Lake Forest College, Lake Forest, Illinois

An old electric razor can be used as an inexpensive vibrator for producing standing waves in a stretched string. The shaving head is removed and one or two feet of fish line or similar cord is tied to the

FIG. 1. Sketch of apparatus using electric razor as a vibrator to produce standing waves in a stretched cord.

arm ordinarily used to activate the shaving head. The razor is supported by means of a large, double, V-jaw condenser clamp[1] and ringstand as shown in figure 1. A small loop is tied at the free end of the cord so that weights may be hung from it.

When the razor motor is started and the proper weights are hung on the lower end of the cord, the cord vibrates in standing waves.

[1] Obtained from any supplier of science apparatus.

Large weights (about 100 grams) are required to tune the cord to its fundamental mode of vibration, while smaller weights result in the various overtones.

If the speed of the motor is varied, several modes of vibration can be produced with the same weight attached. Change of speed can be

FIG. 2. Electrical circuit showing a 1,000 ohm, 25 watt rheostat *R* used to control the speed of electric razor motor *M*.

accomplished simply by connecting a 1,000 ohm, 25 watt rheostat[2] in series with the motor and the AC line. Figure 2 gives the electrical connections required. If a variable autotransformer[3] is available and connected as shown in figure 3, speed variation can also be accomplished.

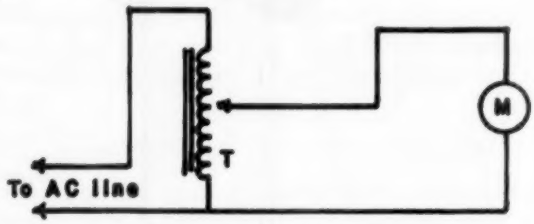


FIG. 3. Electrical circuit showing a variable autotransformer *T* used to control the speed of electric razor motor *M*.

While this apparatus is valuable as a lecture table demonstration for use in teaching principles involved in standing waves and harmonic series, it is also well adapted for use as an exhibit piece. It is easy to manipulate and dramatic in its operation.

[2] Obtained from any radio or electronic supply firm.
[3] Variac or Powerstat.

U. S. T. JOURNAL OF EDUCATION

The Editor recently received Numbers I and II of Volume I of the above Journal from the College of Education, University of Sto. Thomas, Manila. Number I starts with a five stanza poem, "To the Teacher," followed by several messages of congratulations and good wishes from the Vice-Grand Chancellor, the Secretary of Education, and the Dean of the School of Education. Each issue is filled with excellent numbers and model lessons. A few pages in each journal are in the language of the Tagalogs. Congratulations and best wishes.

GLEN W. WARNER, *Editor*
SCHOOL SCIENCE AND MATHEMATICS

RESOURCE UNIT FOR THE STUDY OF THE SOCIAL IMPLICATIONS OF NUCLEAR ENERGY

RICHARD G. TELFER
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Daily the need for electric power is increasing, yet the chief resources for producing this vital power are diminishing. It has been estimated that within less than twenty years the fossil fuels of this country will have to be supplemented if the needs for electrical energy are to be met. Nuclear power reactors can and are supplying electrical power in some areas today and their use will increase as the demands for power increase. General Electric Corporation has a nuclear power reactor functioning near Schenectady, New York and is investing money in similar projects. In Michigan alone plans are taking shape for an estimated ten or twelve power reactors with one already under construction at Monroe.

Evidence is available to show the need for a supplementary source of power; however, much must be done to present evidence that will lessen the fear that now exists in the minds of many citizens with respect to the safety of power reactors.

As education was needed during the issues over fluoridation of city water supplies, so it is needed to bring true facts to the public about living with nuclear devices. To facilitate the expansion of nuclear power programs in the future, an interesting, creative and factual presentation must be made to the youth in school today. These will be the citizens and leaders in a world centered around nuclear energy and it is the responsibility of education to prepare these people for this new challenge.

To help teachers with their presentation of nuclear topics the following resource unit is submitted as a possible solution to this vital educational task.

RESOURCE UNIT FOR THE STUDY OF THE SOCIAL IMPLICATIONS OF NUCLEAR ENERGY

PURPOSE: To help students be aware of the many peacetime social applications of nuclear energy in the world today and in the future.

DESIRED OBJECTIVES:

Skills:

1. Develop within the student the ability to read and listen critically to new items, political issues and the like with respect to materials dealing with nuclear energy.
2. Develop student ability to evaluate the opportunities offered for vocational choice through nuclear energy.

Understandings:

1. To help students understand the importance of nuclear energy to peacetime living.

2. To help students understand their place in a world that is becoming more dependent upon nuclear energy.

Attitudes:

1. To develop within the student the spirit of openmindedness with regard to the use of nuclear energy.

TEACHING TECHNIQUES:

This material need not be limited in use to just the science teachers, but might well work into social studies classes, English class activities and project activities in art and shop classes.

It would be desirable to have students participate in as many different activities as possible. Such things as group work, reports, interviews and project experiences are usable techniques.

Teacher preview of audio-visual aids before presentation to the group is most essential in this subject area.

THE UNIT:

The material that follows is divided into three major headings; suggested topics for study, suggested class activities and suggested resources. Naturally the materials used by any class will depend to a degree on class interest and length of time allowed for the unit. The unit is fastened together in loose leaf form to facilitate addition of new sheets of activities that the individual teacher may deem valuable.

ACTIVITIES

Suggested topics for study	Suggested class activities	Suggested resources
I. Nuclear reactors A. Source of power	Show filmstrip on resources as a kick-off for discussion on future fuel supplies. Through reading have students draw charts that will show extent of fossil fuels and how long they will last at present rate of use. Have students list the types of power reactors and try to determine their imtance for future use. Encourage students to build a model reactor plant that might be suitable as a power source for their community.	Film: *Natural Resources Key to American Strength, New York Times* Monographs: *AEC Reactor Program*, pp. 2–14, U. S. Atomic Energy Comm. Pamphlets: *Atomic Energy Why?* Consolidated Edison Co. *Power Reactor Design* $E=mc^2$, Atomic Power Development Associates, Inc.
B. Source of new understanding	Visit the reactor at the University of Michigan to see many peacetime applications under study. Invite a nuclear scientist to discuss the values of the experimental type reactor.	Places: *Phoenix Project*, Ann Arbor, Mich. People: *A nuclear scientist*
C. Source of public fear	Have students interview people in their community on what they think about a nuclear reactor for a power source in their area. Allow students to prepare chart or display that will present facts about the safety of reactors. Discuss the topic of radiation and hazards resulting from poor safety measures with respect to reactors. Show the civil defense film on radioactive fallout. Stress the radiation factors rather than civil defense techniques.	*The man on the street* Pamphlets: *Atomic Power & Safety*, pp. 5–10, Consolidated Edison Co. *What You Should Know About Radioactive Fallout*, Federal Civil Defense Adm. *27 Questions & Answers*, U. S. Atomic Energy Comm. *ABC's of Radiation*, Brookhaven National Lab. Films: *Radioactive Fallout*, Federal Civil Defense Adm.
II. Medical developments through nuclear research A. Treatment of illness	Show the filmstrip "*Making Atomic Energy Help Mankind.*" Have the students list and give uses of the many different radioisotopes used for treatment of illnesses.	Films: *Making Atomic Energy Help Mankind, Popular Science*

Suggested topics for study	Suggested class activities	Suggested resources
	Arrange for the students to visit a local hospital to see the equipment used for treating illnesses with radioactive materials.	Places: *Local hospital*
	Visit a drug firm or invite a staff person from the company to tell about developments with respect to radioactive materials.	*Parke Davis Co.*, Detroit, Mich. *Upjohn Co.*, Kalamazoo, Mich.
	Have a group of students read about medical treatments with radioactive isotopes and report their findings to the class.	Monographs: *Atomic Energy & Medical Science*, U. S. Atomic Energy Comm.
	Allow time for reports about important scientists in the field of radioactive medical applications. Ex: Curies & Bequerel.	Pamphlets: *The Atom in Our Hands*, pp. 17–18, Union Carbide & Carbon Corp. *Madame Curie*, Metropolitan Life Insurance Co.
	Show the filmstrip "The Story of Radium." Have class compare early techniques with modern day methods of treatment.	Films: *Madame Curie & the Story of Radium*, Metropolitan Life Insurance Co.
B. Diagnosis of illness	Arrange for students to interview a doctor to learn how radioisotopes are used to discover disease.	People: *Local doctor*
	Re-show the filmstrip "Making Atomic Energy Help Mankind"; stress the diagnosis techniques used.	Films: *Making Atomic Energy Help Mankind, Popular Science*
	Have reports on use of radioisotopes for diagnostic purposes.	Pamphlets: *The Petrified River*, pp. 23, Union Carbide & Carbon Corp.
III. Agricultural advances with nuclear energy A. Plant growth studies	Have different class members write to various state agriculture departments to learn of their progress with radioisotope studies of plant growth.	Places: *Agriculture Department of any state* *Botany Department of any leading college or university*
	Visit research project on plant growth, have student try to determine impact of these projects on future food production.	*Phoenix Project*, Ann Arbor, Mich. *Michigan State University*
	Through reading and discussion have class prepare a chart to show some of the uses of radioisotopes in plant studies.	Pamphlets: *The Atom in Our Hands*, pp. 18–21, Union Carbide & Carbon Corp. *The Impact of Atomic Energy on Biology & Medicine*, pp. 4–7, U. S. Atomic Energy Comm.
B. Food preservation	Individual reports by students on experiments conducted in this field.	Pamphlets: *Radioisotopes in Agriculture*, pp. 5–6, American Museum of Atomic Energy
	Investigate work being done by large food packing firms. Write letters or if handy invite a speaker in to discuss the topic "Radiation & Food Preservation."	People: *Food scientist in food processing plant*
C. Pest control measures	Prepare list of insect pests that attack local crops, give the usual method of control. Through reading have class try to determine importance of radiation control methods.	Bulletins: *Applications of Atomic Energy in Plant Science*, pp. 121–127, U. S. Atomic Energy Comm. *Impact of Atomic Energy on Biology & Medicine*, pp. 10, U. S. Atomic Energy Comm.
IV. Industrial uses of radioactive materials A. Regulating quality of products.	Have members of class visit different industries within the community and interview production engineers to learn if and how radioisotopes are serving the industry.	Places: *Local factories* *Ford Steel Mill*, Dearborn *Sutherland Paper Co.*, Kalamazoo, Mich.
	Show the filmstrip "Atoms for Peace" and let students see how products are made better through the use of nuclear devices.	Films: *Atoms for Peace, Life Magazine* Film Service Pamphlets: *The Atom in Our Hands*, pp. 21–23, Union Carbide & Carbon Corp.
	Encourage reports on the use of radioisotopes in gaging thickness of paper, textiles, steel, etc.	

Suggested topics for study	Suggested class activities	Suggested resources
B. Detecting wear in machines or products	Allow a group of students to gather data from oil companies and automobile manufacturers on how radioisotopes are used to indicate wear in automobiles.	Places: *General Motors Corp.*, Detroit, Mich. *Leonard Refineries*
	Using the data gathered have another group of students collect illustrations to show products that have been studied with radioisotopes.	Illustrations: *Magazine ads, Photographs by class member*
V. War or Peace with bomb testing A. Civil defense now or too late	Show civil defense films so that the students will know the force of nuclear blasts and the resulting dangers.	Films: *Operations Cue. What You Should Know About Radioactive Fallout*, Federal Civil Defense Adm.
	Encourage a group to build a display to show the effect of a bomb blast.	People: *Local civil defense leader*
	Invite the local civil defense chairman to discuss "Why Civil Defense."	Films: *Atomic Energy & the United Nations*, McGraw-Hill Co.
B. Our world obligation	Show the filmstrip "Atomic Energy & the United Nations": let class discuss points presented and have each write a theme "Peace with Atoms."	

Sources of Materials

Films:

Federal Civil Defense Administration—Washington, D. C.
Popular Science Films—New York 36, New York
Life Magazine Film Service—New York 20, New York
McGraw-Hill Publishing Co.—New York 18, New York
Metropolitan Life Insurance Co.—New York, New York
New York Times Newspaper—New York, New York

Printed Matter:

U. S. Atomic Energy Energy Commission—Washington, D. C.
American Museum of Atomic Energy—Oak Ridge, Tenn.
Federal Civil Defense Administration—Washington, D. C.
Consolidated Edison Company—New York 3, New York
Union Carbide & Carbon Corporation—New York 17, New York
Atomic Power Development Associates, Inc.—Consumers Power Co. Jackson, Michigan
Brookhaven National Laboratory—Upton, New York
Metropolitan Life Insurance Co.—New York, New York

BACKWARD CHILDREN SHOULD BE HELPED LONG BEFORE SCHOOL AGE

Proper attention to mentally retarded children and their parents when the children are of nursery school age might alleviate difficulties in later life and reduce the population of institutions for the mentally defective.

This conclusion, made as a result of study of a group of retarded pre-school children, was reported to the American Orthopsychiatric Association by Drs. Katherine F. Woodward, Miriam G. Siegal and Marjorie J. Eustis, of the pediatric psychiatry service of Lenox Hill Hospital, New York City.

Parents of the children studied by the New York doctors were all of average intelligence or better. The fathers were professional men or white collar workers. Work with the parents proved to be of major importance in helping the children, the psychiatrists reported. Psychological factors in the parents' make-up and relationship seemed to contribute to the backwardness of the children. Parents and children should receive help very early, as soon as there is any suspicion that the child is retarded, the scientists warn.

A NOTE ON TRANSVERSALS IN TRIANGLES

JOHN SATTERLY
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(1) We start with ***Ceva's Theorem*** and, in case some of our readers may not be familiar with it, I quote it and supply a proof. The theorem is:
"If three concurrent straight lines are drawn from the vertices of a plane triangle to cut the opposite sides then the product of three alternate segments of the sides taken in order is equal to the product of the other three segments."

Thus as in Fig. 1 the three transversals AX, BY, CZ cut the sides

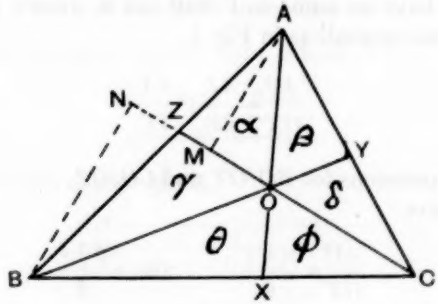


FIG. 1

BC, CA, AB in X, Y, Z, respectively and are concurrent at O. The Theorem states that

$$\text{“}AZ\cdot BX\cdot CY = ZB\cdot XC\cdot YA.\text{”} \tag{1}$$

The ***proof*** depends on the fact that if two triangles stand on the same base their areas are proportional to their altitudes. For example, the triangles AOC, BOC have a common base OC and altitudes AM, BN respectively, therefore

$$\frac{\triangle AOC}{\triangle BOC} = \frac{AM}{BN} = \frac{AZ}{BZ}$$

by similar triangles.

Denote the separate triangles into which triangle ABC is cut up by these transversals by α, β, γ, δ, θ, ϕ (see Fig. 1). Then

$$\frac{AZ}{ZB} = \frac{\beta+\delta}{\theta+\phi}$$

$$\frac{BX}{XC} = \frac{\alpha+\gamma}{\beta+\delta}$$

$$\frac{CY}{YA}=\frac{\theta+\phi}{\alpha+\gamma}$$

Multiply the left hand sides of these expressions to get a new left hand side and the right hand sides to get a new right hand side and we get

$$\frac{AZ}{ZB}\times\frac{BX}{XC}\times\frac{CY}{YA}=1 \tag{1}$$

(2) The second theorem is not so well-known. I forget where I found it. It seems to have no name so I shall call it *Anon's Theorem*. It is, for any three transversals as in Fig. 1.

$$\frac{AO}{OX}=\frac{AZ}{ZB}+\frac{AY}{YC} \tag{2}$$

with similar expressions for BO/OY and CO/OZ.

Proof. We have

$$\frac{AO}{OX}=\frac{\alpha+\gamma}{\theta}, \qquad \text{also}=\frac{\beta+\delta}{\theta}\cdot$$

Apply the algebraical device known as *Componendo* and we get

$$\frac{AO}{OX}=\frac{(\alpha+\gamma)+(\beta+\delta)}{\theta+\phi}\cdot \tag{3}$$

Also

$$\frac{AZ}{ZB}=\frac{\beta+\delta}{\theta+\phi} \quad \text{and} \quad \frac{AY}{YC}=\frac{\alpha+\gamma}{\theta+\phi}$$

therefore

$$\frac{AZ}{ZB}+\frac{AY}{YC}=\frac{(\beta+\delta)+(\alpha+\gamma)}{\theta+\phi}\cdot \tag{4}$$

The right hand sides of Expressions (3) and (4) are equal; therefore also the left hand sides are, that is

$$\frac{AO}{OX}=\frac{AZ}{ZB}+\frac{AY}{YC}\cdot \tag{2}$$

Note: In the case where the sides of the triangle ABC are bisected at X, Y, Z respectively, O is the centroid of the triangle ABC and Equation 2 becomes

$$\frac{AO}{OX}=\frac{1}{1}+\frac{1}{1}=\frac{2}{1}.$$

(3) The next relation is stated in a French Compendium of Elementary Geometry. It is (see Fig. 1)

$$\underline{\frac{AO}{AX}+\frac{BO}{BY}+\frac{CO}{CZ}=2} \tag{5}$$

Proof. We have, using the triangles on the left side of AX,

$$\frac{AO}{AX}=\frac{\alpha+\gamma}{\alpha+\gamma+\theta}$$

and on using the triangles on the right side of AX

$$\frac{AO}{AX}\ \frac{\beta+\delta}{\beta+\delta+\phi}.$$

The Componendo artifice gives

$$\frac{AO}{AX}=\frac{(\alpha+\gamma)+(\beta+\delta)}{(\alpha+\gamma+\theta)+(\beta+\delta+\phi)}.$$

Similarly

$$\frac{BO}{BY}=\frac{(\gamma+\alpha)+(\theta+\phi)}{(\gamma+\alpha+\beta)+(\theta+\phi+\delta)}$$

and

$$\frac{CO}{CZ}=\frac{(\delta+\beta)+(\phi+\theta)}{(\delta+\beta+\alpha)+(\phi+\theta+\gamma)}.$$

Add separately the two sides of these last three expressions and we get

$$\frac{AO}{AX}+\frac{BO}{BY}+\frac{CO}{CZ}=\frac{2(\alpha+\beta+\gamma+\delta+\theta+\phi)}{(\alpha+\beta+\gamma+\delta+\theta+\phi)}=2. \tag{5}$$

Note: If O is the centroid of the triangle ABC this equation becomes

$$\frac{2}{3}+\frac{2}{3}+\frac{2}{3}=2.$$

By the same method we can prove another theorem, viz.

$$\underline{\frac{XO}{XA}+\frac{YO}{YB}+\frac{ZO}{ZC}=1} \tag{6}$$

(4) The next theorem is old; it was probably known to the Greeks and certainly to Leonardo da Vinci in the year 1500 A.D. It is "Let BA, BC (Fig. 2) be any two given straight lines meeting at B and points X and Y taken on BC, BA respectively such that

$$\frac{BX}{BC}=\frac{BY}{BA}=\frac{1}{n}$$

where n is a positive number. Join AX, CY and let O be their intersection. Then shall

$$\frac{XO}{XA}=\frac{YO}{YC}=\frac{1}{n+1} \tag{7}$$

Proof. Join XY, CA. They are parallel and

$$\frac{XY}{CA}=\frac{1}{n}$$

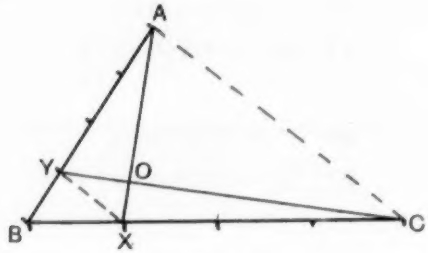


FIG. 2

The triangles OXY, OAC are similar, therefore

$$\frac{XY}{CA}=\frac{XO}{OA}=\frac{YO}{OC}=\frac{1}{n}.$$

Therefore again by Componendo

$$\frac{XO}{XA}=\frac{YO}{YC}=\frac{1}{n+1}. \tag{7}$$

Note 1. If $n=3$; $XO=\frac{1}{4}XA$ and $YO=\frac{1}{4}YC$

Note 2. Leonardo da Vinci used this theorem to prove that the center of gravity of a triangular pyramid (or cone) was one quarter of the way up from the center of the base to the apex of the pyramid (or cone).

(5) This theorem is a variant of the last, but we divide BC and BA by different numbers. Let

$$\frac{BX}{BC}=\frac{1}{m} \quad \text{and} \quad \frac{BY}{BA}=\frac{1}{n}.$$

Proceed with the drawing as in Fig. 2 and in this case get Fig. 3. Then shall

$$\frac{XO}{XA}=\frac{m-1}{mn-1} \quad \text{and} \quad \frac{YO}{YC}=\frac{n-1}{mn-1} \tag{8}$$

Proof. Join XY, CA and draw BO to intersect CA in Z. Apply *Ceva's* theorem to the triangle ABC. Then $AY\cdot BX\cdot CZ=YB\cdot XC\cdot ZA$.

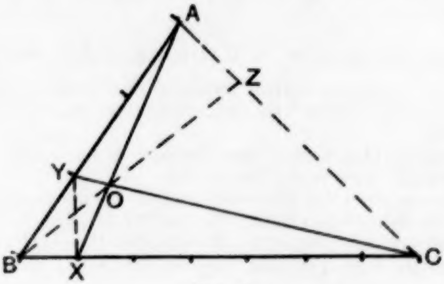


FIG. 3

Replace AY, BX, YB, XC by their values in terms of BA, BC, and the theorem gives

$$\left(\frac{n-1}{n}\ BA\right)\left(\frac{1}{m}\ BC\right)CZ=\left(\frac{1}{n}\ BA\right)\left(\frac{m-1}{m}\ BC\right)\cdot ZA$$

whence

$$\frac{CZ}{ZA}=\frac{m-1}{n-1}. \tag{9}$$

Now apply ***Anon's Theorem*** and we get

$$\frac{AO}{OX}=\frac{AY}{YB}+\frac{AZ}{CZ}=(n-1)+\frac{n-1}{m-1}=(n-1)\ \frac{m}{m-1}$$

whence

$$\frac{XO}{XA}=\frac{(m-1)}{(n-1)m+(m-1)}=\frac{m-1}{mn-1}. \tag{8}$$

Similarly

$$\frac{YO}{YC}=\frac{n-1}{mn-1}. \tag{8}$$

Note 1: If $m=7$ and $n=3$ (as in Fig. 3)

$$\frac{XO}{XA}=\frac{6}{20}=\frac{3}{10} \quad \text{and} \quad \frac{YO}{YC}=\frac{2}{20}=\frac{1}{10}.$$

Note 2: If $m=n$,

$$\frac{XO}{XA}=\frac{YO}{YC}=\frac{1}{m+1}$$

as in Eq. 7.

Also $XY \| CA$, $CZ=ZA$, and BZ is a median of the $\triangle ABC$. This is also easily obtained from Ceva's Theorem.

MULTIPLE TECHNICS IN RADIOGRAPHIC INSPECTION

New technics in combining several sheets of film to examine multi-thickness metal parts in one x-ray exposure was described at the Western Metals Congress, Los Angeles, Calif.

The new technics employ various combinations of sheet film and lead foil, assembled in "sandwich" form in the film holder.

Ralph E. Turner, of the x-ray sales division of Eastman Kodak Company, presented his paper on this subject before the Society for Non-Destructive Testing at one of the 9:30 A.M. sessions in the Ambassador Hotel. His paper is entitled "The Use of Multiple Film Technics to Speed Industrial Radiographic Inspection."

Radiography, one of the foremost methods of non-destructive testing, is used widely in industry to examine metal parts. A single sheet of x-ray film is able to record only a limited range of metal thicknesses. Thus to save the cost involved in setting up more than one exposure for a multi-thickness part, many industries have combined two or more sheets of x-ray film of different film speeds in the film holder.

Under Turner's new technics using 80 to 250 kilovolt radiography, films of different speeds may be selected, and the effective speeds of these films may be adjusted by using lead foil in various combinations with the films, in order to record the widest possible range of metal thicknesses.

These technics were developed and tested at Eastman Kodak Company, which markets several types of x-ray film for both medical and industrial uses.

FEDERAL HELP TO BUILD CLASSROOMS

Federal allocations totaling \$19,701,760, to help build classroom facilities in Federally affected areas, were recently announced by Lawrence G. Derthick, Commissioner of Education, Department of Health, Education, and Welfare.

Seventy-nine school districts in 31 States will receive the aid for construction of new or additional facilities to relieve school overcrowding. The increased enrollments have resulted mainly from the influx of families connected with Federal projects, mostly military installations.

A total of \$45,832,799 in Federal funds, including allocations announced, has been earmarked thus far this fiscal year for classroom construction in Federally affected areas.

Applications from other school districts are being reviewed by the Office of Education.

PROCEDURE TO STRENGTHEN ABILITY TO SOLVE ARITHMETICAL PROBLEMS

JOAN E. BOWERS
Assistant Psychologist, Public School Board, Ottawa, Canada

Problems of all kinds require reasoning by those seeking solutions. Since the ability to reason varies from person to person, a given task may at one time be a problem of insurmountable difficulty, and at another triviality demanding no more thought than is needed for the utterance of "How do you do?" If, by our classroom procedure, we seek to reduce the amount of, or eliminate the necessity for, reasoning, then, to the extent that we are successful, we remove the quality which justifies the name 'problem.' Here we are not calling in question the wisdom of procedures designed to achieve this end (or of procedures which achieve it without design), but are concerned solely with stressing the fact that, in considering whether or not a given task is a problem, we must take into account both the person for whom it is intended and the manner in which he is confronted with it. A more fitting title for those sets of arithmetical diversions frequently labelled 'Problems' would be 'Problems Perhaps,' a remark as applicable to the serial discursive questions styled 'functional units' (whether "pupil originated" or "teacher originated") as to the less chatty, non-sequential units which have successfully resisted the efforts of some writers to reform them out of existence.

The importance of motivation is so generally recognized that it is unnecessary to dwell on this central element in the process of learning. It will be sufficient here to point out that, although 'devices' have a useful place with the younger pupils, their replacement by less ephemeral methods of motivation is desirable as the pupils advance through the grades. Even this advice is qualified by the comment that, while the writer is no advocate of motivation by punishment, she does not belong to the perfectionist school which looks sourly on all extrinsic[1] motivations such as liking for the teacher, the judicious use of tests, and praise for achievement, even the modest achievement of the clumsy but plucky fighter. Extrinsic motivations are not infrequently transformed ultimately into the intrinsic motivation of liking of the subject for its own sake.

To have a chance of solving a problem, the well-motivated pupil must possess certain qualities, among them understanding of the social, commercial or physical situation in which the problem is embedded. He must possess mathematical knowledge such as familiarity with the technical vocabulary, the number facts and the relationships

[1] The adjective "extrinsic" is applied because the motivation is external to the subject.

between quantities, for instance, the number of feet in a yard. He must also have a certain degree of insight into the mathematical processes, such as subtraction or multiplication, by which the solution is achieved. The possession of these attainments is contingent upon an appropriate level of intelligence and upon experience, training or education.

Examples of difficulty created by lack of understanding of the non-mathematical situation are easily found. A pupil who could quickly tell what 4 oranges would cost at 3 cents each might be perplexed in calculating the cost of 4 cinema seats at 3 shillings each or of 4 rutabagas at 3 pesetas each. A pupil capable of calculating the rate per cent per annum if the yearly interest on $97 is $4 might be puzzled in computing the yield on a 4 per cent bond at 97.

Lack of mathematical knowledge is obviously a handicap. A pupil who does not know the meanings of 'difference' and 'product' can only be accidentally successful in finding the difference between 6 and the product of 2 and 4. An average pupil who had often bought postage stamps, but whose knowledge of the four basic operations is confined to addition would have difficulty in solving a problem which required him to find what change he should receive from twenty-five cents after buying four 4-cent stamps.

However, even when a pupil understands the social setting of a problem and appears to be in possession of the necessary mathematical knowledge, he may still be baffled. He may know all the number facts perfectly, but when struggling with a problem may be uncertain whether to add, subtract, multiply or divide. The explanation may lie in the fact that through abundant drill a child can be trained to respond correctly to stimuli such as $13-5$ and $45\div 9$, but remain in a state of vagueness concerning the meanings of $13-5=8$ and $45\div 9=5$. To be of value to him in solving problems, his mathematical knowledge must fulfil two criteria: *it must be accurate and it must be functional.* Thorough drill may give accuracy, but if the instruction is dominantly repetitive, the accurate response may be non-functional in the arithmetical problems of the classroom and in those encountered outside the school. Children do not (or should not) learn that 8 9's are 72 for its own sake or for its conversational value at a bridge table, but for use in the business of life. Understanding must come through teaching directed towards that end or through experience gained in work or play in the home or out of doors; accuracy and speed are products of well-motivated drill. Success in the solution of problems requires both kinds of teaching.

Even if the pupil's understanding of the social setting and of the relevant mathematical processes is adequate and if his knowledge of the technical vocabulary, the number facts and the relationship be-

tween units of measurement is accurate, there may still be obstacles in the path leading to the solution. It is one thing to be able to deal with the steps in a problem *separately*, but another to *combine* them so as to yield a solution. This is true for exercises as well as for problems. The fact that a pupil can (a) find a least common denominator, (b) change fractions to equivalent fractions either by multiplication or division of the numerators and denominators, (c) add fractions with like denominators, and (d) convert improper fractions to mixed numbers provides no guarantee that he can mobilize these abilities in adding the fractions 7/12 and 9/20.

$$\frac{7}{12}+\frac{9}{20}$$

$$=\frac{35}{60}+\frac{27}{60} \qquad \text{Abilities (a) and (b)}$$

$$=\frac{62}{60} \qquad \text{Ability (c)}$$

$$=1\,\frac{2}{60} \qquad \text{Ability (d)}$$

$$=1\,\frac{1}{30} \qquad \text{Ability (b)}$$

If the writer could have assumed that facility in the several operations would ensure facility in their synthesis, her task in constructing diagnostic tests would be greatly simplified.

It seems likely that ability to combine steps thoroughly understood in isolation is closely related to intelligence. This problem in educational psychology lends itself to attractive experimental work.

* * *

Lack of motivation, unfamiliarity with the non-mathematical circumstances surrounding a problem, inadequacy of insight into the mathematical operations such as addition and division, defective technical vocabulary, ignorance of the relationship between quantities of the same kind, inaccurate rote knowledge, weakness in combining steps which are understood in isolation, and mental dullness are not the only causes of inability to solve problems. To them should be added chaotic written solutions, hindrances of an emotional character, and occasionally doubt on the part of a teacher concerning the procedures most likely to have value in imparting to pupils the desired ability.

Frequently, it is advised that pupils should be actively encouraged

to write neat, coherent solutions. The advice is good, but it should be remembered that one probable cause of confused written solutions is confusion in the thought processes which give rise to them. The writing of neat solutions may help, but cannot guarantee, the occurrence of orderly thinking. Clever children should be encouraged to write the most succinct solutions of which they are capable. The acme of elegance in a solution is attained when it consists solely of the answer.

The adaptation of the teaching of arithmetic to very dull pupils lies outside the scope of this paper. Advice on this subject and on the treatment of emotional difficulties may be found in books dealing with the education of atypical children.

* * *

Reference has been made to methods likely to help pupils in the solution of problems. Before discussing this matter, a fundamental question may be considered. Since

1. the solution of problems requires reasoning;
2. at best, reasoning is often slow, hesitant and beset with error;
3. a fraction of the pupils, far from inconsiderable, is incapable of unaided reasoning except under very simple circumstances;
4. arithmetic is a highly utilitarian subject for all except number theorists and is a dubious means of teaching pupils to reason;
5. efficiency in the business transactions of everyday life renders desirable a rapid and accurate (or reasonably accurate) treatment of the problems that arise;
6. all or most of the common problems within the ability of elementary school pupils have been solved concisely and may be found in textbooks;

is it not pedantry to bother school children with problems at all? Should they not be placed quickly in possession of the solution templates and be freed for more useful or interesting occupations.

What everyone knows may be revealed first. There are those who scornfully reject this frankly utilitarian proposal, but whose practice implies its unqualified acceptance. If we make a *synthetic* approach to the solution, asking the sequential questions that 'home' the pupils to the solution, then, however admirable in content and form our questions may be, however deftly we deal with the answers elicited, however freely we apply the term 'developmental' to our treatment, we have done the pupils' thinking and removed the problem from the category of problems. If, after the template has been fashioned, we provide a set of 'problems' for the pupils to do in the manner to which we are accustoming them, we are not teaching the solution of prob-

lems. We have conducted a ***demonstration*** of the method of solution and followed the demonstration with a set of drill exercises.

It may be mentioned here that this process of co-operative reasoning, or the appearance of it, is probably of benefit to pupils incapable of all but the most rudimentary reasoning in that they will carry into adult life some memory of the solution of useful problems, but it is probably injurious to the brighter pupils who, being reduced unnecessarily to intellectual dependence upon the teacher, may be rendered distrustful of their own mental power.

Research on the problem of problems is not sufficiently mature to warrant a judgment that the developmental synthetic method has no place, or has a minor place, in the teaching of arithmetic. However, it can be said that, unless the accepted meaning of 'problem,' whether mathematical or non-mathematical, is distorted we should cease calling the method the "teaching of problems." The cause of clear thinking will be served if into our educational vocabulary we incorporate the phrase 'verbal exercises' to designate tasks which were formerly genuine problems but which by the method of presentation employed have lost their status as problems. 'Verbal exercises' might also be used as the name of tasks in which the non-mathematical setting varies, but in which the type of mathematical operation remains constant.

The following suggestion[2] for dealing with arithmetical problems may seem hackneyed and colorless to some people, but its rests firmly on the belief that a problem departs from its status as problem in proportion to the extent of the teacher's intrusion on the pupil's thinking:

1. Deal with the social setting of the problem drawing as fully as is necessary on all devices available to the teacher, such as excursions, films, slides, pictures, diagrams, dramatization and supplementary reading.
2. Teach, or effect the recall of, the required mathematical information. If doubt exists concerning the pupils' insight into a mathematical operation, this uncertainty should be removed.
3. Provide motivation for the problem. It may be sufficient to ensure sustenance of motivation previously provided.
4. Follow the time-honored formulae:[3]

What are we required to find?
What are we given that may help us to find it?

---

[2] We shall refer to this procedure as the Primary Procedure. The Secondary Procedures are used only with those pupils unable to solve a given problem even after judicious assistance.

[3] By some, these few questions are regarded as constituting a method of teaching. The view taken here is that they are useful 'focussing' questions which the teacher should quickly discard and the pupils quickly adopt for independent, silent use.

5. Leave the pupils undisturbed for a time.

6. Move quietly from desk to desk encouraging those who are disheartened, reluctantly asking a guiding question of those likely to give up effort because of a feeling of inferiority, and leading successful pupils to new and more rewarding pastures.

7. Use one of the Secondary Procedures described below for pupils who, after reasonable effort and grudgingly given assistance, are unable to solve the problem.

Four Secondary Procedures, so-called because they are used only after the pupils have tried to think for themselves, will now be mentioned.

1. *The Substitution of Miniatures*

For the original problem is substituted an oral, piecemeal treatment of parallel problems in which no numbers or very small ones are used.

2. *The Cumulative Technique*

The constituent sub-problems are isolated and their solution on paper is attempted. If success attends the pupils' efforts, a progressive synthesis is tried.

3. *The Method of Analysis-Synthesis*

The pupils are trained to work backward from the required answer to the data. When the analysis is completed, it gives the clue to the ordinary synthetic solution.

4. *The Synthetic Development Method*

In the method of Analysis-Synthesis, after completion of the analysis, the pupils are expected to work out the ordinary synthetic solution unaided. However, in the Synthetic Development method, no analysis is done, but by a series of questions the teacher conducts the pupils directly forward from data to answer. This is the method to which allusion was made on page 488.

The following problems will be used in illustrating the first three Secondary Procedures:

(a)

What would be the cost of waxing a rectangular livingroom floor 14 feet long and 12 feet wide at 2 cents per square foot?

(b)

A tank when filled holds 6000 gallons of water. If a gallon of water weighs 10 pounds, how many tons of water would the tank contain when one-third full?

The Substitution of Miniatures

(a)

1. How would you find the cost of sanding 100 square feet if you know the cost per square foot?

2. What would be the cost of painting 10 square feet at 1 cent per square foot?
3. What would be the cost of painting 10 square feet at 3 cents per square foot?
4. How many square feet are there in a rectangle 5 feet long and 4 feet wide?
5. How many square feet are there in a rectangular floor 14 feet long and 12 feet wide?
6. What would be the cost of waxing a rectangular livingroom floor 14 feet long and 12 feet wide at 2 cents per square foot?

(b)

1. What is one-half of 80?
2. What is a third of 90 yards?
3. If a gallon of water weighs 10 pounds, what is the weight of 2 gallons? Of 6 gallons? Of 100 gallons?
4. How many pounds are there in 1 ton?
5. How many tons are there in 4,000 pounds? In 6,000 pounds? In 20,000 pounds?
6. The original problem.

The Cumulative Method

(a)

1. What is the area in square feet of a rectangular floor 15 feet long and 14 feet wide?
2. What is the cost of waxing 250 square feet of floor at 3 cents per square foot?
3. The original problem.

(b)

1. A tank when full holds 12,000 gallons of water. How many gallons does it contain when one-third full?
2. What is the weight in pounds of 3,000 gallons of water if a gallon weighs 10 pounds?
3. A tank when full holds 6,000 gallons of water. If a gallon of water weighs 10 pounds, how many pounds of water will be in the tank when it is one-third full?
4. How many tons are there in 8,000 pounds? In 14,000 pounds?
5. The original problem.

The Method of Analysis-Synthesis

(a)

1. What are we required to find?
2. In order to find the cost of waxing the floor, what must we know?

$$\text{Cost of waxing}\begin{cases}\text{Number of square feet}\\ \text{Cost per square foot}\end{cases}$$

3. Are we given either of them?

$$\text{Cost of waxing}\begin{cases}\text{Number of square feet}\\ \text{Cost per square foot (2¢)}\end{cases}$$

4. To find the number of square feet in a rectangular room, what must we know?
5. Are we given this information?

$$\text{Cost of waxing}\begin{cases}\text{No. of sq. ft.}\begin{cases}\text{No. of ft. in length (14)}\\ \text{No. of ft. in width (12)}\end{cases}\\ \text{Cost per square foot (2¢)}\end{cases}$$

The pupils should then be given an opportunity of writing the ordinary synthetic solution:

$$\begin{array}{ll} \text{Number of square feet in area} & = 14\times 12 \\ \text{Cost of waxing floor} & = 14\times 12\times 2 \text{ cents} \\ & = 336 \text{ cents} \\ & = \$3.36 \end{array}$$

(b)

1. What are we required to find?
2. To find the number of tons of water, what must we know?

$$\text{No. of tons of water}\left\{\begin{array}{l} \text{Number of pounds of water} \\ \\ \text{Number of pounds per ton} \end{array}\right.$$

3. Do we know either of these?

$$\text{No. of tons of water}\left\{\begin{array}{l} \text{No. of pounds of water} \\ \\ \text{No. of pounds per ton (2,000)} \end{array}\right.$$

4. To find the number of pounds of water, what must we know?

$$\text{No. of tons of water}\left\{\begin{array}{l} \text{No. of pounds of water}\left\{\begin{array}{l} \text{No. of gallons of water} \\ \text{No. of pounds per gallon} \end{array}\right. \\ \text{No. of pounds per ton (2,000)} \end{array}\right.$$

5. Do we know either of these?

$$\text{No. of tons}\left\{\begin{array}{l} \text{No. of pounds}\left\{\begin{array}{l} \text{No. of gallons} \\ \text{No. of pounds per gallon (10)} \end{array}\right. \\ \text{No. of pounds per ton (2,000)} \end{array}\right.$$

6. To find the number of gallons what must we know?

$$\text{No. of tons}\left\{\begin{array}{l} \text{No. of pounds}\left\{\begin{array}{l} \text{No. of gallons}\left\{\begin{array}{l} \text{Total no. of gals. held} \\ \text{Fraction of tank used} \end{array}\right. \\ \text{No. of pounds per gallon (10)} \end{array}\right. \\ \text{No. of pounds per ton (2,000)} \end{array}\right.$$

7. Are we given this information?

$$\text{No. of tons}\left\{\begin{array}{l} \text{No. of pounds}\left\{\begin{array}{l} \text{No. of gals.}\left\{\begin{array}{l} \text{Total no. of gals. held (6,000)} \\ \text{Fraction of tank } (\frac{1}{3}) \end{array}\right. \\ \text{No. of pounds per gal. (10)} \end{array}\right. \\ \text{No. of pounds per ton (2,000)} \end{array}\right.$$

Then the pupils should try to write the synthetic solution:

$$\begin{array}{ll} \text{No. of gallons of water in tank} & = \frac{1}{3}\text{of } 6{,}000 \\ & = 2{,}000 \\ \text{Hence, no. of pounds of water} & = 2{,}000\times 10 \\ \text{And no. of tons of water} & = \dfrac{2{,}000\times 10}{2{,}000} \\ & = 10 \end{array}$$

* * *

A few comments will be made on certain of these procedures. We

have pointed out that the ability to do steps one at a time provides no guarantee of ability to combine them. Yet, the ability to combine steps mastered singly is assumed in the Cumulative Technique. What is likely to happen is that a percentage of the weak pupils, large or small depending upon their intelligence, will be able to weld the steps, For those unable to combine the steps, one or more of the other Secondary Procedures may then be tried.

* * *

Sometimes it is said that, in conducting an analysis, the teacher is guiding the pupils' thinking just as much as when the Synthetic Development method is used. It should be noted, however, that use of the Analytic-Synthetic method prior to the Primary Procedure is not recommended. ***Analysis is conducted by the teacher only when the pupils have failed and are unable to do the analysis unaided.*** It should also be noted that the analytic procedure is widely used as a method of discovery and the synthetic procedure as a mode of demonstration subsequent to discovery.

Those who give analysis a trial and discard it because the hope of quickly gained success is not realized are reminded that skill in analysis is not readily acquired by pupils and that a period of two or three years may be necessary before its advantages become apparent.

Undoubtedly, facility in analysis will be most quickly gained by those in least need of it, the pupils of superior intelligence.

COOPERATIVE EDUCATIONAL RESEARCH

Twenty agreements for cooperative educational research, to be conducted by colleges, universities, and State departments of education, were approved by the Office of Education, Department of Health, Education, and Welfare, during January and February, Commissioner of Education Lawrence G. Derthick announced.

In addition, the Office of Education plans to direct and coordinate two research projects—retention of students and school construction—in cooperation with several colleges and universities.

The Office of Education has earmarked $416,131 for these 22 projects in 1957. Cooperating institutions also will contribute funds to the project.

Eleven of the agreements concern education of the mentally retarded. These will be conducted by Columbia University, New York, N. Y. (two projects); George Peabody College for Teachers, Nashville, Tenn.; University of North Carolina, Chapel Hill; University of Texas, Austin; Wayne State University, Detroit, Mich.; University of Georgia, Athens; Southern Illinois University, Carbondale; and the Iowa, Kansas, and Nebraska departments of education.

Other research projects approved during the two-month period include: Special abilities of pupils, University of Chicago, Ill., and University of Michigan, Ann Arbor; juvenile delinquency, Syracuse University, N. Y. (two projects); retention of students, Iowa State Department of Public Instruction; staffing the schools, Syracuse University, N. Y., and University of Florida, Gainesville; social climate among high school students, University of Chicago, Ill.; and measuring the quality of school curricula, New York State Department of Education.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

2557. *Proposed by John Satterly, Toronto, Canada.*

In any $\triangle ABC$ if G is the centroid, I the incenter, R the circumradius and r the inradius, prove

$$\overline{GI}^2=\tfrac{1}{3}(bc+ca+ab)-\tfrac{1}{9}(a^2+b^2+c^2)-4Rr$$

Solution by A. R. Haynes, Tacoma, Wash.

Let O be the circumcenter and H be the orthocenter of $\triangle ABC$. Now G, the centroid lies on OH such that

$$OG=2GH \quad \text{or} \quad OG=\tfrac{1}{3}OH. \tag{1}$$

Assume that $\triangle ABC$ to be such that I does not fall on OH, i.e., having a triangular relationship of the points I, O, H with I the vertex and OH, the base. Let the projections of IO, IH upon the base be ON and NH respectively.

In

$$\triangle IGO,\ \overline{GI}^2=\overline{IO}^2+\overline{OG}^2-2\overline{OG}\cdot\overline{ON} \tag{2}$$

and in $\triangle IGH$:

$$\overline{GI}^2=\overline{IH}^2+\overline{GH}^2-2\overline{GH}\cdot\overline{NH}. \qquad (3$$

Now by (1)

$$\overline{GH}=2\overline{OG} \quad \text{and} \quad NH=3\overline{OG}-\overline{ON} \tag{4}$$

Sub (4) in (3), solve for $\overline{ON}$ in (2) and (3) and equate:

$$3\overline{IG}^2=2\overline{IO}^2+\overline{IH}^2-6\overline{OG}^2 \tag{5}$$

Using the following formulae:

$$\overline{IO}^2=R^2-2Rr^*$$

* Johnson, *Modern Geom.*, p. 205.

$$\overline{OG}^2=R^2-\frac{a^2+b^2+c^2}{9}\dagger$$

$$\overline{IH}^2=4(R^2-2R\cdot r)+(bc+ca+ab)-(a^2+b^2+c^2)\ddagger$$

Substituting, combining times, etc.

$$\overline{IG}^2=\tfrac{1}{3}(bc+ca+ab)-\tfrac{1}{9}(a^2+b^2+c^2)-4Rr.$$

ck. in $\triangle$, I, G, O, H coincide

$$R=\frac{a\sqrt{3}}{3},\quad r=\frac{a\sqrt{3}}{6}$$

$$\therefore\quad \overline{IG}^2=\frac{3a^2}{3}-\frac{a^2}{3}-\left[4\cdot\frac{a\sqrt{3}}{3}\cdot\frac{a\sqrt{3}}{6}=\frac{2a^2}{3}\right]=0.$$

2558. *Proposed by A. R. Haynes, Tacoma, Wash.*

Using the relation $e^{ix}=\cos x+i\sin x$, show

$$e^{-\pi/2}=i^i \quad (1) \qquad e^i=i^{1/\pi} \quad (3)$$

$$e^\pi=i \quad (2) \qquad \pi=-2\log i^i \quad (4)$$

Solution by C. W. Trigg, Los Angeles City College

Let $x=\pi/2$, then

$$e^{\pi i/2}=i$$

$$e^{-\pi/2}=i^i. \tag{1}$$

Taking natural logarithms of both sides of (1),

$$-\pi/2=\ln i^i$$

$$\pi=-2\ln i^i. \tag{4}$$

Let $x=-\pi$, then

$$e^{-\pi i}=-1$$

$$e^\pi=(-1)^i=i^{2i}. \tag{2}$$

Let $x=\pi$, then

$$e^{\pi i}=-1$$

$$e^i=(-1)^{1/\pi}=i^{2/\pi} \tag{3}$$

The errors in the given relations are evident.

Solutions were also offered by Ann Causala, East Rutherford, N. J.; W. R. Talbot, Jefferson City, Mo.; Walter R. Warne, St. Petersburg, Fla.; and the proposer.

2559. *Proposed by Vincent C. Harris, San Diego, Calif.*

What is the locus of a point such that the angle subtended by a fixed segment is constant?

Solution by C. W. Trigg, Los Angeles City College

The plane locus of the vertex of a constant angle, ϕ, subtended by a fixed line segment consists of two arcs of circles, one on each side of the segment, in which ϕ may be inscribed. If ϕ is a right angle, the locus is a circle.

The three-dimensional locus is the surface formed by rotating the arcs about the segment as an axis. For $\phi<\pi/2$, the locus is an "apple," for $\phi=\pi/2$ it is a sphere, for $\phi>\pi/2$ it is a "bobbin."

† Johnson, *Modern Geom.*, p. 173.

‡ Mackay: Referred to by Johnson in note on p. 189.

Solutions were also offered by Julian H. Braun, San Diego, Calif.; Alan Wayne, Baldwin, N. Y.; and the proposer.

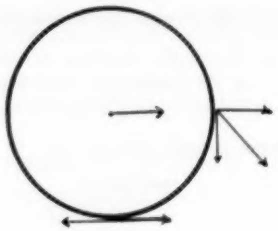
2560. *Proposed by Julius Sumner Miller, El Camino California.*

A wheel is rolling uniformily along a horizontal road. Is there any point of the rim which has a velocity which is straight up or straight down.

Solutions by Curtis Boyd Menning, Holland, Mich.

Vectorily speaking the actual velocity of any point of a wheel is the sum of its relative velocity with respect to the center of the wheel and the actual velocity of the center. Assuming no slippage, the magnitude of the two vectors, concerning points on the rim, are both equal to WR. W is the rotational velocity of the wheel and R is its radius. By closed polygons, the resultant velocity will be the diagonal of a special parallelogram, namely a rhombus. Since the diagonal of a rhombus can never be perpendicular to any of its sides, there is no point on such a wheel whose actual velocity is straight upward or straight downward.

It can also be seen from the drawing that the direction of the resultant vector approaches a vertical position at the same instant its magnitude approaches zero.



A solution was also offered by Julian H. Braun, San Diego, Calif.

2561. *Proposed by Brother Felix John, Philadelphia, Pa.*

A certain number is the product of three prime factors, the sum of whose squares is 2331. There are 7560 numbers (including unity) which are less than the number and prime to it. The sum of its divisors (including unity and the number itself) is 10,560. Find the number.

Solution by The Proposer

Let N equal the required number, and p, q, r be its three prime factors. Then

$$N=pqr.$$

Also,

$$p^2+q^2+r^2=2331. \tag{1}$$

Since p, q, and r are prime numbers, the number of numbers less than each and prime to each is respectively: $(p-1)$, $(q-1)$, and $(r-1)$. Hence, the number of numbers less than N and prime to it is their product. That is,

$$(p-1)(q-1)(r-1)=7560. \tag{2}$$

The mathematical formula for the sum of the divisors of $N(=pqr)$ is

$$S=(p^{n+1}-1)/(p-1)\times(q^{n+1}-1)/(q-1)\times(r^{n+1}-1)/(r-1),$$

where n equals 1 since p, q, and r are prime numbers.

Hence,

$$(p+1)(q+1)(r+1)=10{,}560. \tag{3}$$

Expand the lefthand members of equations (2) and (3), and subtract equation (2) from equation (3):

$$2pq+2pr+2qr=2998. \tag{4}$$

Add equations (1) and (4) and simplify:

$$(p+q+r)^2=5329 \quad \text{or} \quad (p+q+r)=73. \tag{5}$$

Now, add equations (2) and (3):

$$2pqr+2(p+q+r)=18{,}120 \quad \text{or} \quad pqr+(p+q+r)=9060. \tag{6}$$

Substituting from equation (5) in equation (6):

$$pqr=8987=N.$$

Check: By trial, the prime factors of 8987 are 11, 19, and 43 respectively.

$$11^2+19^2+43^2=121+361+1849=2331.$$

$$10\times18\times42 \text{ does }=7560 \quad \text{and} \quad 12\times20\times44=10{,}560, \text{ also.}$$

Solutions were also offered by Sister Margaret Ann, Long Beach, Calif.; J. H. Means, Huston-Tillotson College; W. R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; Alan Wayne, Baldwin, N. Y.

2562. *Proposed by Hugo Brandt, Chicago, Illinois.*

If

$$a\sqrt{(s-a)^2-b(2s-b)}=(a+s)^2$$

and

$$b\sqrt{(s-b)^2-a(2s-a)}=(b+s)^2$$

show that

$$ab=s^2 \quad \text{if} \quad a\neq b.$$

Solution by W. R. Talbot, Jefferson City, Missouri

Because the two radicals are the same, division gives

$$\frac{a}{b}=\frac{(a+s)^2}{(b+s)^2}.$$

Clearing, expanding, and collecting give

$$s^2(a-b)-ab(a-b)=0.$$

If $a\neq b$,

$$s^2=ab.$$

A solution was also offered by the proposer.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2581. *Proposed by J. H. Means, Austin, Texas.*

It has been proved that a rational number x between 0 and 1 may be represented uniquely in the form

$$x = a_1/2! + a_2/3! + \cdots + a_n/(n+1)!$$

where $0 \leq a < k$, for $k = 2, 3, \cdots, n$. For example $2/3 = 1/2! + 1/6!$.
Write 3/7 in the above form.

2582. *Proposed by the Plane Geometry Class of Benjamin Russell High School, Alexander City, Ala.*

If AM is a median of triangle ABC, prove that AM is less than $1/2(AC+AB)$.

2583. *Proposed by Helen S. Clark, San Diego, Calif.*

Find the equation of the line joining the circumcenter and the incenter of a triangle.

2584. *Proposed by A. T. Emerson, Coronado, Calif.*

I. Let $P_1(x_1, y_1)$, $P_2(x_2, y_2)$ $P_3(x_3, y_3)$, $P_4(x_4, y_4)$ be the vertices of a quadrilateral lettering so that in traversing the perimeter from P_1 to P_2 to P_3 to P_4 one would have the area always on his left. Find a formula, expressed in a form of a determinant, for the area.

II. Let $P_1(x_1, y_1)$, $P_2(x_2, y_2)$, $P_3(x_3, y_3)$, $P_4(x_4, y_4)$, $P_5(x_5, y_5)$ be the vertices of a pentagon with lettering as in I. Find a formula, expressed in a form of a determinant, for the area.

III. Is it possible to find a formula, expressed in a form of a determinant, for a convex polynomial of n sides?

2585. *Proposed by Curtis Boyd Manning, Holland, Mich.*

Assuming a spherical Earth, at what latitudes would a plumb line be maximumly deviated from true "plumb" due to the rotation of the Earth?

2586. *Proposed by Cecil B. Read, Wichita, Kans.*

Solve:

$$x + y = 2b$$

$$x^4 + y^4 = 2b^4$$

BOOKS AND PAMPHLETS RECEIVED

GENERAL GEOGRAPHY FOR COLLEGES, by O. D. Von Engeln, Ph.D., *Cornell University*, and Bruce Carlton Netschert, Ph.D., *Resources for the Future, Inc.* Cloth. Pages xiii+681. 17.5×25 cm. 1957. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $7.50.

GENERAL COLLEGE CHEMISTRY, by Jesse Hermon Wood, *Professor of Chemistry*, and Charles William Keenan, *Associate Professor of Chemistry, The University of Tennessee.* Cloth. Pages viii+689. 16×23.5 cm. 1957. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $6.50.

PUTTING ARITHMETIC TO WORK, by Dale Carpenter, *Mathematics Supervisor, Secondary Division, Los Angeles City School Districts*, and Elizabeth Cuthbertson, *Teacher of Mathematics, North Hollywood Junior High School, Los Angeles.* Cloth. 346 pages. 15.5×22 cm. 1957. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $2.52.

APPLYING ARITHMETIC, by Dale Carpenter, *Mathematics Supervisor, Secondary Division, Los Angeles City School Districts*, and George F. Drake, Jr,. *Teacher of Mathematics, Van Nuys High School, Los Angeles.* Cloth. 378 pages. 15.5×22 cm. 1957. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $2.52.

MODERN SCIENCE AND CHRISTIAN BELIEFS, by Arthur F. Smethurst, Ph.D., *Treasurer and Canon Residentiary of Salisbury Cathedral.* Cloth. Pages xx+300. 13.5×21.5 cm. 1955. Abingdon Press, New York, N. Y. Price $4.00.

EXPERIMENTAL PSYCHOLOGY AND OTHER ESSAYS, by I. P. Pavlov. Cloth. 653 pages. 13×21 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

PHYSICS—A MODERN APPROACH, by L. Paul Elliott, *Late Professor of Physical Sciences, University of Florida,* and William F. Wilcox, *Assistant Professor of Physics, Eastern Michigan College.* Cloth. Pages xi+658. 16.5×23.5 cm. 1957. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.12.

BARUCH SPINOZA. THE ROAD TO INNER FREEDOM, Edited by Dagobert D. Dunes, *Doctor of Philosophy of the University of Vienna.* Cloth. 215 pages. 13×20 cm. 1957. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.00.

THE FIRST ONE HUNDRED AND FIFTY YEARS. A HISTORY OF JOHN WILEY AND SONS, INC., by The House of Wiley. Cloth. Pages xxv+242. 18.5×25.5 cm. 1957. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.50.

COLLEGE GEOMETRY, by Leslie H. Miller, *Associate Professor of Mathematics, The Ohio State University.* Cloth. Pages x+201. 15×23.5 cm. 1957. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $4.50.

ARITHMETIC: ITS STRUCTURE AND CONCEPTS, by Francis J. Mueller, *Chairman, Department of Mathematics, Maryland State Teachers College, Towson, Maryland,* Cloth. Pages xv+279. 15×23 cm. 1956. Prentice-Hall, Inc., 70 Fifth Avenue. New York 11, N. Y. Price $5.50.

INTRODUCTION TO FINITE MATHEMATICS, by John G. Kemeny, J. Laurie Snell, and Gerald L. Thompson, *Department of Mathematics, Dartmouth College.* Cloth. Pages xi+372. 14×21.5 cm. 1957. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

ALGEBRA, BOOK TWO, Revised Edition, by A. M. Welchons, W. R. Krickenberger, and Helen R. Pearson, *The Arsenal Technical High School, Indianapolis, Indiana.* Cloth. Pages x+582. 15×23 cm. 1957. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.68.

ERNEST RUTHERFORD, ATOM PIONEER, by John Rowland. Cloth. 160 pages. 11.5×18.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

BOY'S BOOK OF FROGS, TOADS, AND SALAMANDERS, by Percy A. Morris, *Chief Preparator, Peabody Museum of Natural History, New Haven, Connecticut.* Cloth. Pages v+240. 14×21.5 cm. 1957. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $4.00.

ATOMIC QUEST, A PERSONAL NARRATIVE, by Arthur Holly Compton, *Distinguished Service Professor of Philosophy, Washington University, St. Louis.* Cloth. 370 pages. 14.3×20.6 cm. 1956. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $5.00.

FOUNDATIONS OF RADIO, by M. G. Scroggie, B.Sc., M.I.E.E. Sixth Edition. Cloth. 349 pages. 13.5×21.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

AMERICA'S NATURAL RESOURCES, by Charles H. Callison, *Natural Wildlife Federation.* Cloth. Pages v+211. 13×20.5 cm. 1957. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $3.75.

WORKING WITH CHILDREN IN SCIENCE, by Clark Hubler, *Wheelock College*. Cloth. Pages viii+425. 16×23 cm. 1957. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $5.50.

AUTOMATION: ITS PURPOSE AND FUTURE, by Magnus Pyke, B.Sc., Ph.D., F.R.I.C., F.R.S.E. Cloth. 191 pages. 13×21 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

HOW TO SOLVE IT. A NEW ASPECT OF MATHEMATICAL METHOD, by G. Polya, *Stanford University*. Second Edition. Paper. Pages xii+253. 10×18 cm. 1957. Doubleday and Company, Inc., 575 Madison Avenue, New York 22, N. Y. Price 95 cents, $1.10 in Canada.

ANATOMICAL ATLAS, by Maud Jepson, M.Sc. Paper. 25 pages. 21.5×28 cm. 1957. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price 75 cents.

DISSECTION GUIDES, by H. G. Q. Rowett, M. A., *Lecturer in Zoology at Plymouth Technical College* Paper. The Frog, 63 pages, The Dogfish, 62 pages, The Rat with Notes on the. Mouse, 64 pages, The Rabbit, 32 pages, Invertebrates, 56 pages. 18×25 cm. 1957. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price 95 cents each.

THE CHEMICAL INDUSTRY FACTS BOOK, Third Edition, by Manufacturing Chemists' Association, Inc. Paper. Pages ix+149. 14×23 cm. 1957. Manufacturing Chemists' Association, Inc., 1625 Eye Street, N. W., Washington 6, D. C. Price $1.25.

AN EXPERIMENTAL STUDY OF ARITHMETIC PROBLEM-SOLVING ABILITY OF SIXTH GRADE BOYS, by Sister Mary Camille Kliebhan, M.A., *Congregation of the Sisters of the Third Order of St. Francis of Assisi, Milwaukee, Wisconsin.* Paper. Pages viii+51. 14.5×23 cm. 1955. The Catholic University of America Press, 620 Michigan Avenue, N.E., Washington 17, D. C. Price $1.00.

SCIENCE TEACHING TECHNIQUES, PART V, sponsored by the Science Teachers' Joint Sub-Committee. Paper. 48 pages. 14×21.5 cm. 1957. John Murray, Albemarle Street, London, W.1. England. Price 3s.net.

FREE RADICALS IN ROASTED COFFEE, by John P. O'Meara, Frank R. Truby, and Thomas M. Shaw, *Southwest Research Institute, San Antonio, Texas.* Paper 6 pages. 15×23 cm. March, 1957. The Coffee Brewing Institute, Inc., 551 Fifth Avenue, New York 17, N. Y.

BOOK REVIEWS

MODERN SCIENCE AND CHRISTIAN BELIEFS, by Arthur F. Smethurst, Ph.D., M.A., B.Sc., D.I.C., A.R.C.S., F.G.S., F.C.S. *Treasurer and Canon Residentiary of Salisbury Cathedral; Examining Chaplain to the Bishop of Salisbury.* Cloth. Pages xx+300. 13.5×21.5 cm. 1955. Abingdon Press, New York. Price $4.00.

This is a book that many in all walks of life have been wanting. It may not satisfy them but it will help to clear their thoughts. For years people have been questioning. Does modern science disprove the scripture? How does a great divine interpret the Bible? Is there any real connection between science and Christianity? The author is a man who is prepared to answer many questions in this category. He has an honors degree as a Bachelor of Science, obtained his Ph.D. degree from the University of London doing research in geology and geochemistry. He is a fellow of the Geological Society, the Chemical Society, and the Mineralogical Society. He has an honors degree in theology from Oxford.

So he writes from the viewpoint of both a scientist and a theologian. The book is in three parts. Part I, "General Questions," gives the presuppositions of modern science. Here are discussions of the scientific method starting with a quotation from the great little book by Einstein and Infeld, ***The Evolution of Physics***. Before one reads far he realizes that the author has a thorough knowledge of the field of modern science and understands what he has read. In this part also are references to the works of the 17th century scientists and their religious beliefs. The attributes of a good research scientist, the objects of research, and the limitations of science round out the introductory section.

Part II is made up of a short chapter on the physical sciences, a much longer chapter on the biological sciences, and a chapter on the nature of human character. To read the section on the physical sciences, which is nearly all on the subject of physics, the reader should have some acquaintance with relativity, the quantum theory, and entropy. The size of the universe is also briefly discussed. Almost anyone can read the discussion of the biological sciences. Here is a section on the origin of life and discussion of that vague series of forms known as the viruses which contains the shadowy boundary between the living and the non-living. Evolution, natural selection and genetics are briefly but clearly discussed. This chapter closes with a section on some possible answers to the question of pain and cruelty in the biological world.

In the third chapter of Part II, "The Nature of Human Character," the reader will find much that demands careful thought. Here is just one example: "The recent trend of physiological research admittedly raises many problems for the Christian doctrine of the future life; but although, on account of our entire ignorance of the details of that future state, we can never hope to find a complete or detailed answer to these difficulties, yet the doctrine of the resurrection of the body is infinitely more acceptable than the doctrine of the immortality of the soul." Much more should be said here, but you must read; one cannot afford to miss this section.

Part III of this great book contains two sections to discuss some problems of conflict between Christians and scientists. The first is on miracles, the second on creeds. No special training is needed here. If you pass over all the rest of the book, you should at least not miss these two chapters. Many Christian ministers and laymen will not accept some of his viewpoints on the miracles described in the Gospels; some scientists will reject his statements on others. In the chapter on creeds he will, of course, be disputed. He is a leader in the church of England, so can be expected to follow closely its principal beliefs. To some of these Roman Catholics will seriously object; to others, leaders of thought in the various protestant denominations will also object. He closes with a quotation from Sir William Bragg: "Some people say that religion and science are opposed; so they are, but only in the same sense as that in which my thumb and forefinger are opposed—and between the two one can grasp everything."

G. W. W.

General Geography for Colleges, by O. D. Von Engeln, Ph.D., *Cornell University*, and Bruce Carlton Netschert, Ph.D., *Resources for the Future, Inc.* Clare M. O'Gorman, Cartographer. Cloth. Pages xiii+681. 17.5×26 cm. 1957. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price. $7.50.

The field of geography is so great that any author or group of authors must make the selection of the sections of the subject they consider most important. The long years of work in the field by the authors of this book has given them an unusual grasp of the field and of the student minds that will use the book. The authors use the first part of the book to discuss the physical characteristics such as the great bodies of water and of land, the growth of cities determined by their location and surroundings, a brief study of the principals of cartography and meteorology. Following this is the major portion of the text which consists of regional geography. Climatic conditions are discussed and the various sections

of the world falling in each major climatic type are treated in one group. Thus under the general heading, Medium-Temperature Humid Climates, three chapters discuss (1) The Mediterranean Climate, (2) The Humid Sub-tropical Climate, and (3) The Marine West Coast Climate. In the first of these three the region around the Mediterranean Sea is given a full discussion but other regions of the world where similar conditions prevail are also mentioned, such as the region near the Cape of Good Hope, the Southern part of the Australian continent, and portions of Chile and California. Thus all parts of the globe where like conditions prevail are discussed in one chapter or group of chapters. Excellent maps are in abundance. One of these may be used to show a feature not always found. A little more than half of page 265 shows a relief map of the Iberian Peninsula. A white line across the northern part divides it into two main sections: the southern large section with a Mediterranean climate and the northern section mostly in the Marine West Coast Climate. A section of the United States is shown for comparison of size. Here the section covers much of Wyoming and Colorado and extends eastward into Nebraska. Thus each climate section of the world is well covered. The book is remarkably well illustrated with wonderful photographs, maps and diagrams. Following the text is a section of six pages listing excellent reading material, divided into references for each chapter. The material is so fundamental and complete that the authors recommend its use as a first book on world geography for both those who choose geography as a major and for those who want only a year's work for help in a related subject.

G. W. W.

THE FIRST ONE HUNDRED AND FIFTY YEARS. A HISTORY OF JOHN WILEY AND SONS, INC., by The House of Wiley. Cloth. Pages xxv+242. 18.5×25.5 cm. 1957. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.50.

This beautiful book is a model of the fine craftsmanship of the company and a wonderful history of the progress of a century-and-a-half of growth. If the founder, Charles Wiley, had been able to look ahead into the future, he no doubt would have been utterly astonished at the outgrowth of his modest printing shop and bookstore opened in that memorable year 1807, the birthyear of two of our greatest poets. But he could not look far into the future so little is left to tell of the early work of his print-shop. He died in 1826 and left the business to his son John, who continued with various partners and firm names until 1875, when the firm became John Wiley and Sons. This is not just a book of the history of the firm but contains much of the history of the early productions of American authors. In 1821 Cooper's *The Spy* appeared, followed by others by the same author. In 1845 Poe's *Tales* and *The Raven and Other Poems* were published, and the following year *Mosses from an Old Manse* by Hawthorne. In the beginning only about one-third of the firm's publications were by American authors, but by 1848 most of its publications were in the home field and were largely scientific books. Now every science is represented by its greatest authors and many of their best productions: biology, chemistry, physics, geography, geology, physiology, mathematics, statistics, and all the fields of engineering. The book is adorned by numerous photographs of the Wileys and their officers, some of their office rooms at 440 Fourth Avenue, and examples of their book covers through the years. The book is a model of precision and of the art of book making. The chapters are written by specialists in their fields, Professors in our great Universities, Officers of our great research laboratories, and a few chapters by members of the firm of John Wiley and Sons, Incorporated.

G. W. W.

ENGINEERING PROBLEMS, by Charles Angevine Hutchinson, Leon Watson Rutland, Jr., and Walter Wayne Varner, *Department of Applied Mathematics in the College of Engineering, University of Colorado.* Cloth. Pages vii+181.

17.5×25 cm. 1956. Harper Brothers, 49 East 33d Street, New York 16, N. Y. Price $3.00.

Here is an excellent text for a short course of engineering problems for college freshmen. As practically no college mathematics is required in advance it can be used parallel to the regular college courses in algebra, trigonometry and analytics. The slide rule is used in the beginning so students become thoroughly familiar with the various scales and can use them in all their later courses. Students also learn how to prepare neat engineering papers with correct methods of lettering. Emphasis is given to approximate numbers, the various tables of logarithms, square and cube roots, exponential and hyperbolic functions. Trigonometry and curve plotting give students practical use of the mathematics courses while they are taking the elementary mathematics. Another chapter describes the more common computing machines and gives their use in the solutions of problems. Still other chapters deal with topics from mechanics, electricity and a few paragraphs and problems from the field of modern physics. Many of the problems throughout the book leave blanks so that the dimensions may be supplied by the instructor when assignments are made. Sample exercise sheets are given in the appendix.

G. W. W.

MATH CAN BE FUN, Teacher Edition, by Louis Grant Brandes, 1956, 200 pages $8\frac{1}{2}\times 11$ in., offset printed. Net school price, $2.50 per copy. J. Weston Walch, Publisher, Box 1075, Portland, Me.

MATH CAN BE FUN, Student Edition, 154 pages, same as above but without answers and appendix. Price $2.00. A Teacher Edition free with 10 or more Student Editions.

This is a book of particular interest for the teacher who is overburdened with large classes of pupils of varying ability and interests. Many youngsters will work on a puzzle with enjoyment and persistence when an ordinary assignment will evoke no interest. It is put up for pupils in grades 7 to 10 but many others, both below and above, will enjoy it. The contents consist of (1) Number Oddities such as interesting number relationships, magic squares and rapid calculation; (2) Puzzles; (3) Tricks and Games for both individual and class use; (4) Facts and Stories; (5) Self Tests; (6) Optical Illusions; (7) Recreational problems; and (8) Linkages. The Teacher Edition gives the answers and contains an appendix giving a descriptive bibliography, suggestions to teachers, and an index of subjects and titles. A preliminary edition of this book met with extraordinary enthusiasm and praise.

G. W. W.

A COLLECTION OF CROSS-NUMBER PUZZLES, Teacher Edition, with answers, teacher section and index, by Louis Grant Brandes. 226 pages. J. Weston Walch, Publisher, Box 1075, Portland, Maine.

A COLLECTION OF CROSS-NUMBER PUZZLES, Student Edition (without answers, teacher section and index), 156 pages. Price, $2.00. One copy of teacher edition free with orders for ten or more copies of student edition.

This is a book of 104 puzzles requiring nearly 3000 computations, some very easy and some fairly complex. They include work with whole numbers, fractions, decimals, per cent, powers, square root, measures, perimeters, areas and volumes. The book is a good way to interest pupils and keep them busy at worth-while jobs. Forty or more cartoons add spice and humor.

G. W. W.

THE ENJOYMENT OF MATHEMATICS, SELECTIONS FROM MATHEMATICS FOR THE AMATEUR, by Hans Rademacher and Otto Toeplitz, translated by Herbert Zuckerman. Cloth. Pages iii+204. 16.5×24 cm. 1957. Princeton University Press, Princeton, N. J. Price $4.50.

The introduction points out that this is not a book attempting to show the usefulness of mathematics, nor is it concerned with mathematical games and pastimes, nor with the philosophical foundations of mathematics. Instead, an attempt is made to show to the non-mathematician certain types of phenomena, methods of proposing problems, and methods of solving problems. Although it may be true that no background is required other than elementary algebra and plane geometry, this reviewer doubts that many with only this minimum will really enjoy and fully appreciate this book.

The scope of material covered is rather broad, as indicative of some of the topics: the four color map problem; is the number of primes infinite (also, is the number of primes *of certain types* infinite?); what is the smallest circle that will enclose a finite set of points; Waring's problem; what is the triangle of shortest perimeter that can be inscribed in a given triangle; the regular polyhedrons; Pythagorean numbers and Fermat's theorem; approximation of irrational numbers by means of rationals; perfect numbers; curves of constant breadth; periodic decimal fractions. The treatment is more complete and rigorous than often found in books for the amateur; as examples one might cite the discussion of the existence and number of the regular polyhedrons, the factorization of a number into prime factors, or the theorem on arithmetic and geometric means.

The professional mathematician (including of course the teacher) will certainly want this book in his own library, not only for places where topics are discussed more completely yet on a more elementary level than is often the case, but for the pleasure of seeing a new approach to many problems. Certainly the book should be in every college or university library, and it will also be a valuable addition to any high school library. Certainly many high school students will be challenged and intrigued by much of the material.

CECIL B. READ
University of Wichita

THE LEIBNIZ-CLARKE CORRESPONDENCE, by H. G. Alexander, *Lecturer in Philosophy in the University of Manchester.* Cloth. Pages lvi+200. 12×18.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

The correspondence in question, between Leibniz and Samuel Clarke, was an important portion of the controversy between Leibniz and the English school headed by Newton. Originally concerned over priority in the invention of the calculus, the controversy spread to other matters, including issues involving theology and philosophy. The correspondence, originally published in 1717, has been considered one of the most outstanding 18th century philosophical controversies. It is pointed out that the material has not been reprinted in full in English since 1738.

An introduction, covering some sixty pages, is particularly valuable in helping to orient the reader who may not be too familiar with the controversy. This discusses the origin of the correspondence, and makes a careful analysis of the argument. There is some space devoted to more recent contributions to the space-time controversy; perhaps the statement is well phrased: "it is perhaps best to call it a drawn contest."

Appendices include selected extracts from Newton's *Principia* and from the *Opticks.*

CECIL B. READ

THE BEQUEST OF THE GREEKS, by Tobias Dantzig. Cloth. 191 pages. 13.5×21 cm. 1955. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Price $3.95.

No better statement of the content of this book can be made than the first sentence in the preface, " . . . a study of problems, principles and procedures which modern mathematics has inherited from Greek antiquity." The first three chapters (On Greeks and Grecians; The Founders; On the Genesis of Geometry) are

almost entirely descriptive. The author has some very fine phrasing of his thoughts. From this point on the reviewer seemed to gain the impression of a gradually increasing trend from description to presentation of problems and methods.

Some chapters seemed especially valuable: The Crescents of Hippocrates; The Quadratrix of Hippias (Here we find the statement that this is the first curve other than the circle of which we have any historical record). The chapter headed "The Pseudomath" could be profitably read by any high school student intrigued by the problem of angle trisection ro squaring the circle and could profitably be read by many teachers.

Certainly this book should be in both high school and college library. Not everyone will appreciate all portions, but much can be appreciated by even the sophomore high school student. It is a fine supplementary book for courses in the history of mathematics. Some statements tend to be rather striking, others suggest possibilities for further exploration. As indicative, by no means exhaustive: "*He lived in Alexandria.* These four words sum up all we know of the life of the man who was instrumental in shaping the mathematical education of countless generations, and one of whose works has had, next to the Bible, perhaps the largest circulation of any book ever written." Or, the discussion of the analogy between periodic continued fractions and perilodic decimal fractions. Again, the final sentence in one chapter seems a challenge, "And this problem of *transcendental arithmetic*, has, as far as I know, not even been tapped."

The final chapter, entitled "Epilogue," essentially a summary, is exceptionally thought provoking.

CECIL B. READ

ELECTRONICS, THE SCIENCE OF ELECTRONICS IN ACTION, by A. W. Keen, M.I.R.E., A.M.I.E.E. Cloth. Pages 256. 14.0×21.0 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

Fashions in phrasing the advances in science change with the years. Ten years ago the title of this book might have been "Some Newer Applications of Electricity." Then, usefulness of electricity was largely associated with its current. Electrons were known, of course, but chiefly of concern to the theorists.

So, here we find many of electricity's well known, and many new, services reassessed with the electron the unit of explanation. In seventeen chapters, with a two-page double-columned index, electrons are passed in review, mostly in terms of services to modern mechanical devices. The approach is made through the tool-aspects of electrons. Chapter titles: Conductors; Controls; Beam tubes; Signals; Circuit elements and Circuit processes illustrate the pattern. More specific are: Audio-electronics; Broadcasting; Radar; Television and Switching, Counting and Computing.

The verbal presentation is terse and, at times, deficient in clarity by reason of its brevity. Use of hazardous analogies, glamorous superlatives and appeal to miracle-magic of the popularizers is not made. Understanding is helped by 191 line-drawn figures with clarifying legends. Specific applications are illustrated by fifty photographs in the form of thirty full-page plates.

The text is entirely non-mathematical description. Readers with a background of high school physics should be able to follow with understanding though the going may be a bit labored at times.

The author, an Oxford (England) man, has had some twenty years experience as a teacher, radio engineer and in research employment in the fields of radar and television.

This book is desirable for the high school science libraries and for the convenient use of all teachers of physical sciences.

B. CLIFFORD HENDRICKS
Longview, Washington

NEW ERA OF FLIGHT, AERONAUTICS SIMPLIFIED, by Lewis Zarem and Robert

Maltby. Cloth. 176 pages, 16×24 cm. 1956. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $3.75.

This is an excellent informative source of information on types of aircraft currently in use. Included are good pictures of the many kinds of aircraft to aid in distinguishing one from another. Flight instruments and various electronic devices needed in aviation as it is today are described as well as explanations of their use.

The many problems associated with flight at high altitudes and at supersonic speeds are discussed. Some information is given as to how man is proceeding to reach high altitudes and move through the sound barrier.

Here is an interesting up-to-date account with pictures of our new military aircraft with what can be expected of each. The book is easily read and can furnish a lot of enjoyment to anyone interested in aviation. The reader not familiar with aviation can find the book written in an understandable authoritative approach so as to make it interesting.

This book can be recommended to be included as a part of any book collection on aviation. The secondary school student can find useful material for the use in study of related aviation studies.

The authors have used good foundation technics along with pertinent facts and pictures on every page. The young was well as the old should find many answers to their every day questions related to aviation.

NELSON L. LOWRY

DANISH ATOMIC SCIENTIST AWARDED $75,000 PRIZE

Prof. Niels Bohr, Danish atomic physicist and teacher, was named recipient of the first $75,000 Atoms for Peace Award. Prof. Bohr, now 71 years old, opened up a whole new era in the field of atomic physics when, at 28, he presented a basic theoretical work on the structure of the atom and contributed materially to clarification of the basic concepts of quantum physics. For his work, he was awarded the Nobel Prize in Physics in 1922. Since 1920, the Danish scholar has been director of the Institute for Theoretical Physics at Copenhagen which was founded on his initiative.

The award was presented by Dr. James R. Killian Jr., chairman of the Board of Trustees of Atoms for Peace Award. The Award "grew out of an appeal from President Eisenhower" made on July 20, 1955, at Geneva, Switzerland. It was created in response to the President's appeal as a memorial to Henry and Edsel Ford. One million dollars was authorized to be used at the rate of $100,000 a year for 10 years "for the advancement of the science of atomic energy for peaceful purposes. . . . " Dr. Killian said of Prof. Bohr, "His humanity, his goodness and wisdom—in addition to his outstanding scientific contributions—have inspired the many scholars who have been his students and colleagues to become a nucleus of international understanding and goodwill.

"During the years since World War II, Prof. Bohr has been active, not only in the operation of his distinguished Institute with its international body of scholars, but he has also actively and devotedly urged international cooperation in developing the peaceful uses of atomic energy. Toward this end, he has privately and publicly expressed his 'fervent hope that the progress of science might initiate a new era of harmonious cooperation between nations.' "

In addition to the honorarium of $75,000, Prof. Bohr received a medallion, designed by Sidney Waugh, and cast in gold.

It is more desirable to be approaching truth perpetually than to attain it.
—LESSING
